Estimates of fish, spill, and juvenile fish bypass passage efficiencies of radio-tagged juvenile salmonids relative to spring and summer spill treatments at John Day Dam in 2003

Final Report of Research during 2003

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Submitted to:

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Submitted:

December 30, 2004

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Summary

Spring

From 27 April through 05 June 2003, 1389 radio-tagged yearling Chinook salmon of hatchery origin were released 23 km above John Day Dam (JDA) to compare the effects of 0% day spill and 45% night spill (00/45 treatment) to 0% day spill and 60% night spill (00/60 treatment) on yearling Chinook salmon passage.

- No significant differences in yearling Chinook salmon passage via non-turbine routes (fish passage efficiency; FPE), the spillway, or the juvenile fish bypass were found between treatments when diel operating periods were pooled (Summary Table 1).

- Neither day nor night FPE or day bypass system passage differed significantly between treatments when diel operating periods were pooled, but significant differences in passage via the spillway and juvenile bypass were present during the night (Summary Table 1).

- The treatments resulted significant changes in passage via the spillway and juvenile bypass, but the changes offset each other and resulted in no overall significant difference in FPE. This result is similar to previous studies of 12- and 24-h spill at John Day Dam.

Summary Table 1. Pooled and diel passage estimates (Est) of yearling Chinook salmon during 00/45 and 00/60 spill treatments at John Day Dam, spring 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at α = 0.05 level.

Diel Period	Passage efficiency	00/45 Est	00/45 95% LCRI	00/45 N	00/60 Est	00/60 95% LCRI	00/60 N
Pooled	FPE	83.6	80.6-86.4	686	85.7	83.0-88.2	605
	SPE	47.4	40.0-54.9	686	56.7	49.7-63.6	605
	JBYPE	36.2	29.2-43.6	686	29.0	22.9-35.7	605
Day	FPE[1]	79.0	73.0-84.3	204	75.0	68.8-80.6	200
	SPE	-	-		-	-	
	JBYPE	77.5	71.4-82.9	204	74.5	68.3-80.2	200
Night	FPE	85.9	80.3-90.5	482	90.2	85.8-93.8	405
	SPE *	70.1	62.4-77.2	482	80.5	74.2-85.9	405
	JBYPE *	15.8	11.9-20.3	482	9.8	6.9-13.2	405

1: FPE was not exactly equal to JBYPE during the no-spill period due to small amounts of spill and fish passage via the spillway during block 10.

Summer

- From 22 June through 19 July 2003, 4122 subyearling Chinook salmon of hatchery origin were radio-tagged and released 23 km above JDA to compare the effects of 0% day spill and 60% night spill (12-h treatment) to 30% day spill and 30% night spill (24-h treatment) on fish passage behavior.

- No significant difference in overall subyearling Chinook salmon FPE during the pooled diel periods was detected between treatments, but passage via the spillway was significantly lower and passage via the juvenile bypass were significantly greater during the 12-h than the 24-h treatment (Summary Table 2).

- Diel estimates of FPE, spillway passage, and passage via the juvenile bypass all differed significantly between the 12- and 24-h treatments. Day and night FPE, and night passage via the spillway, were significantly greater for the treatment with the greatest percent spill in each diel period, while day and night passage via the juvenile bypass were greatest during the treatment with the lowest percent spill in each diel period (Summary Table 2).

- Our results indicate that for radio-tagged subyearling Chinook salmon arriving at JDA equally distributed between day and night spill conditions (similar to this study), the potential differences in overall FPE between 12- and 24-h spill treatments were reduced by compensatory shifts in fish passage via the spillway or juvenile bypass, as opposed to significant changes in the proportion of fish passing via the turbines. This would also be expected to be true of run-of-the-river fish whose arrival time at JDA was equally dispersed throughout the diel period under similar conditions. However, significant differences in diel estimates of FPE between the 12- and 24-h treatments related to the percent spill also indicate that, if fish arrival times are not similar during the day and night, the FPE would be maximized if the greatest percent spill was during the diel period that most fish arrived at the dam.

Summary Table 2. Pooled and diel passage estimates (Est) of subyearling Chinook salmon during 12- and 24-h spill treatments at John Day Dam, summer 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at $\alpha = 0.05$ level.

Diel period	Passage efficiency	12-h			24-h		
		Est	95% LCRI	N	Est	95% LCRI	N
Pooled	FPE	70.7	64.7-76.4	1401	74.8	69.5-79.7	1691
	SPE *	48.1	38.7-57.6	1401	61.7	53.1-69.9	1691
	JBYPE *	22.6	17.8-28.0	1401	13.1	9.6-17.1	1691
Day	FPE *	47.5	38.2-57.0	557	81.5	75.6-86.5	1003
	SPE	-	-	-	70.4	59.9-79.6	1003
	JBYPE *	47.6	40.4-54.8	557	11.1	8.0-14.8	1003
Night	FPE *	86.0	82.3-89.3	844	65.1	59.7-70.3	688
	SPE *	79.9	75.2-84.0	844	49.1	43.1-55.2	688
	JBYPE *	6.2	4.2-8.6	844	16.0	12.5-20.0	688

Introduction

A Supplemental Biological Opinion issued by the National Marine Fisheries Service (NMFS) in 1998 recommended that spill volumes at dams on the Columbia and Snake rivers be maximized to increase juvenile salmonid (*Oncorhynchus* spp.) survival without exceeding the current total dissolved gas (TDG) cap or other project-specific limitations (NMFS 1998). At John Day Dam (JDA), completion of spillway flow deflectors increased the potential for greater spill volumes at this project while remaining under the TDG cap. Thus, the NMFS recommended that 24-h spill studies be initiated at JDA in 1999 as a means of increasing fish passage efficiency (NMFS 1998). At JDA, juvenile salmonids pass the dam via non-turbine routes through the spillway or the juvenile-fish-bypass system (JBS).

Generally, a 1:1 ratio is assumed between the percentage of total fish that pass via the spillway and the percentage of total river flow discharged through the spillway (spill effectiveness; Whitney et al. 1997). However, recent studies at JDA indicate that spill effectiveness is greater than 1:1. Whitney et al. (1997), using hydroacoustic methods, estimated a spill effectiveness of 2.2:1 during 36% spill discharge for spring migrants and a spill effectiveness of 1.1:1 during 73% spill for summer migrants. Similarly, in a study using radio telemetry at John Day Dam in 1999, Hansel et al. (2000) reported spill effectiveness values ranging from 1.1:1 to 2.4:1, depending on species and spill treatment.

In 1999, 2000, 2002, and 2003, the U.S. Army Corps of Engineers (USACE) contracted with the U.S. Geological Survey (USGS) to determine fish and spill passage efficiencies (FPE, SPE) of radio-tagged juvenile salmonids at JDA during various 12- and 24-h spill treatments. These studies have consisted of combinations of mean percent spill discharges of 0 or 30% during the day and mean spill discharges ranging from 30 to 60% at night (Hansel et al. 2000, Beeman et al. 2003; Beeman et al. In preparation). In 2003, the study was divided into spring (yearling Chinook salmon migration) and summer (subyearling Chinook salmon migration) periods. In spring, two 12-h spill treatments were proposed consisting of 0% day spill (0700 to 1859 hours) and 45 or 60% night spill (1900 to 0659 hours). During summer, the proposed treatments consisted of a 12-h spill treatment of 0% day spill and 60% night spill, and a 24-h spill treatment of 30% day spill and 30% night spill. Our specific objectives were to: 1) determine the proportion of radio-tagged yearling and subyearling Chinook salmon (*O. tshawytscha*) passing through the spillway, powerhouse, and JBS at JDA during the two spill treatments, and 2) obtain information on the behavior of radio-tagged fish in the near-dam area prior to passage.

Methods

Study Site

John Day Dam is located on the Columbia River at river km 347 (Figure 1). The dam consists of a single powerhouse of 16 turbine units, 4 skeleton bays, and a single spillway of 20 tainter gates. Both powerhouse and spillway are perpendicular to river flow. A navigation lock is located at the north end of the dam.

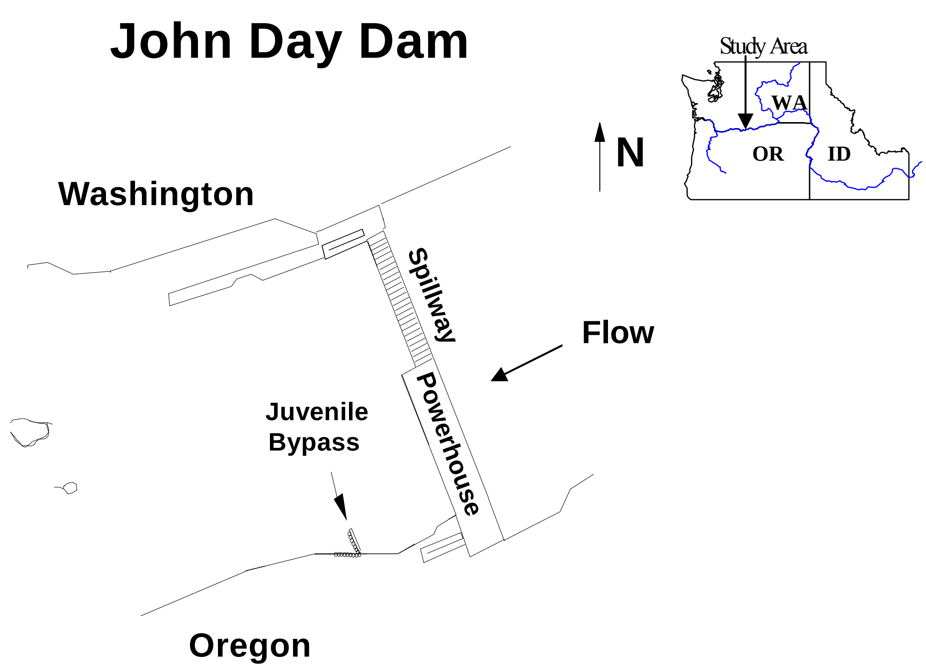

Figure 1. John Day Dam study site at Columbia River km 347.

Study Design and Dam Operations

The spring and summer study designs consisted of 4-d blocks with alternating 2-d treatments using a randomized block design (Table 1). In spring, a 2-d treatment of 0% day spill and 45% night spill (00/45 treatment) was alternated with a 2-d treatment of 0% day spill and 60% night spill (00/60 treatment). During summer, a 2-d treatment of 0% day and 60% night spill (12-h treatment) was alternated with a 2-d treatment of 30% day and 30% night spill (24-h treatment). Hourly powerhouse and spillway discharge data were obtained from the USACE (2003) and compiled for each study period.

Fish Tagging, Handling, and Release

Yearling and subyearling Chinook salmon of hatchery origin were obtained from the Smolt Monitoring Program at JDA and were held at the collection facility for 12- to 24-h before being implanted with radio transmitters. Fish free of major injuries, severe descaling, external signs of gas bubble trauma, or other obvious abnormalities were gastrically implanted using the methods of Martinelli et al. (1998).

Pulse-coded radio transmitters operating at frequencies between 150.320 and 150.760 MHz were used so individual fish could be recognized. Two sizes of these transmitters were used to accommodate the different sizes of the spring and summer migrants. Transmitters implanted in yearling Chinook salmon were 7.3 mm in diameter x 18.0 mm in length and weighed 1.40 g in air and 0.80 g in water (model 3KM; Lotek Wireless, Newmarket, Ontario, Canada[1]) and those implanted in subyearling Chinook salmon were 6.3 mm x 4.5 mm x 14.5 mm long and weighed 0.85 g in air and 0.50 g in water (Lotek Wireless model NTC-3-1).

Fish were held in tanks at the collection facility for 20 to 28 h after tag implantation to allow fish time to recover from the procedure. At the end of the recovery period, the holding tanks were checked for mortalities before the fish were transported to

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1 Reference to trade names does not imply endorsement by the U.S. Government.

Table 1. Spring and summer study designs at John Day Dam, 2003.

Spring			Summer		
Block	Date	Spill treatment	Block	Date	Spill treatment
1	24-Apr-03	0 day/45 night	**1**	9-Jun-03	30 day/30 night
	25-Apr-03	0 day/45 night		10-Jun-03	30 day/30 night
	26-Apr-03	0 day/60 night		11-Jun-03	0 day/60 night
	27-Apr-03	0 day/60 night		12-Jun-03	0 day/60 night
2	28-Apr-03	0 day/60 night	**2**	13-Jun-03	30 day/30 night
	29-Apr-03	0 day/60 night		14-Jun-03	30 day/30 night
	30-Apr-03	0 day/45 night		15-Jun-03	0 day/60 night
	1-May-03	0 day/45 night		16-Jun-03	0 day/60 night
3	2-May-03	0 day/60 night	**3**	17-Jun-03	30 day/30 night
	3-May-03	0 day/60 night		18-Jun-03	30 day/30 night
	4-May-03	0 day/45 night		19-Jun-03	0 day/60 night
	5-May-03	0 day/45 night		20-Jun-03	0 day/60 night
4	6-May-03	0 day/45 night	**4**	21-Jun-03	30 day/30 night
	7-May-03	0 day/45 night		22-Jun-03	30 day/30 night
	8-May-03	0 day/60 night		23-Jun-03	0 day/60 night
	9-May-03	0 day/60 night		24-Jun-03	0 day/60 night
5	10-May-03	0 day/45 night	**5**	25-Jun-03	0 day/60 night
	11-May-03	0 day/45 night		26-Jun-03	0 day/60 night
	12-May-03	0 day/60 night		27-Jun-03	30 day/30 night
	13-May-03	0 day/60 night		28-Jun-03	30 day/30 night
6	14-May-03	0 day/60 night	**6**	29-Jun-03	30 day/30 night
	15-May-03	0 day/60 night		30-Jun-03	30 day/30 night
	16-May-03	0 day/45 night		1-Jul-03	0 day/60 night
	17-May-03	0 day/45 night		2-Jul-03	0 day/60 night
7	18-May-03	0 day/60 night	**7**	3-Jul-03	30 day/30 night
	19-May-03	0 day/60 night		4-Jul-03	30 day/30 night
	20-May-03	0 day/45 night		5-Jul-03	0 day/60 night
	21-May-03	0 day/45 night		6-Jul-03	0 day/60 night
8	22-May-03	0 day/60 night	**8**	7-Jul-03	0 day/60 night
	23-May-03	0 day/60 night		8-Jul-03	0 day/60 night
	24-May-03	0 day/45 night		9-Jul-03	30 day/30 night
	25-May-03	0 day/45 night		10-Jul-03	30 day/30 night
9	26-May-03	0 day/45 night	**9**	11-Jul-03	0 day/60 night
	27-May-03	0 day/45 night		12-Jul-03	0 day/60 night
	28-May-03	0 day/60 night		13-Jul-03	30 day/30 night
	29-May-03	0 day/60 night		14-Jul-03	30 day/30 night
10	30-May-03	0 day/45 night	**10**	15-Jul-03	0 day/60 night
	31-May-03	0 day/45 night		16-Jul-03	0 day/60 night
	1-Jun-03	0 day/60 night		17-Jul-03	30 day/30 night
	2-Jun-03	0 day/60 night		18-Jul-03	30 day/30 night
11	3-Jun-03	0 day/45 night	**11**	19-Jul-03	30 day/30 night
	4-Jun-03	0 day/45 night		20-Jul-03	30 day/30 night
	5-Jun-03	0 day/60 night		21-Jul-03	0 day/60 night
	6-Jun-03	0 day/60 night		22-Jul-03	0 day/60 night

Rock Creek, Washington (23 km upstream of JDA), where they were motored by boat into the northern half of the Columbia River near the creek mouth and released. Regurgitated tags were removed from the transport containers immediately before release when present. Radio-tagged fish were divided equally between releases at 0900 and 2100 hours to disperse the arrival of fish at JDA over the diel period.

Telemetry Receiving Equipment

Radio-tagged fish were detected near JDA with four-element Yagi (aerial) and underwater antennas (standard dipole antennas as described by Beeman et al. 2004; Figure 2). Aerial antennas were positioned along the forebay sides of the powerhouse

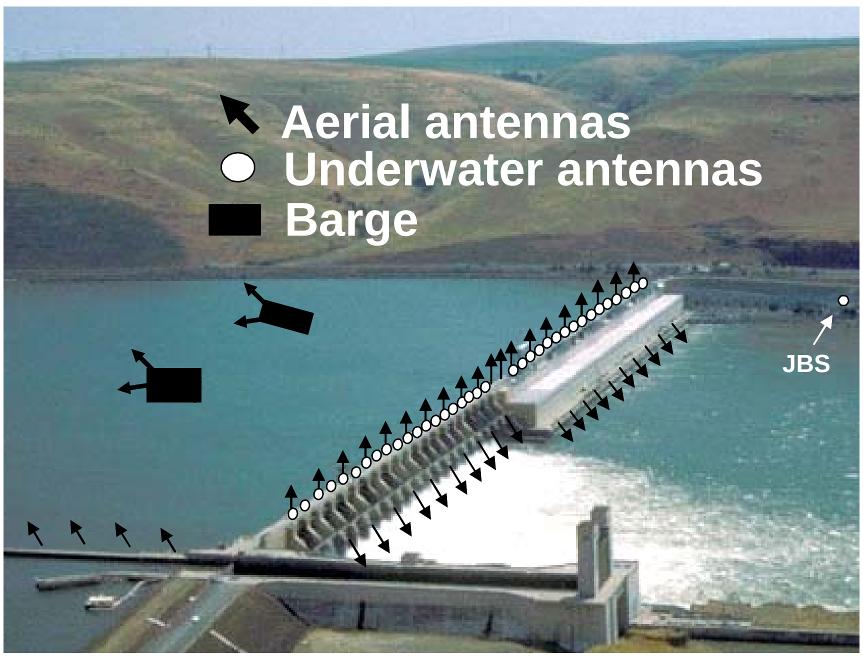

Figure 2. General locations of aerial and underwater antennas at John Day Dam during spring and summer, 2003. JBS = Juvenile fish bypass system.

and spillway to detect fish within about 100 m of the dam face (near-dam area). Each aerial antenna monitored the area in front of a pair of turbine units, skeleton bays, or spill bays. Additionally, 4 aerial antennas mounted on a pair of barges were used to detect radio-tagged fish at an upriver entrance station about 600 m upstream of the dam (boat-restricted-zone boundary), 20 aerial antennas mounted to the tailrace side of the dam were used to detect fish in the powerhouse and spill basin areas of the tailrace, and 1 aerial antenna on the Washington and Oregon shore were used to detect fish at an exit station 5.3 km downriver from the dam. The aerial antennas were connected to SRX-400 receivers that recorded the telemetry data, using the methods of Hensleigh et al. (1999). Each SRX-400 receiver was configured to scan all attached aerial antennas combined (master antenna), until it received a signal and then to cycle through individual aerial antennas (auxiliary antennas), scanning each frequency for a period of 3 sec, to determine a more precise location of the transmitter.

Underwater antennas were used to detect radio-tagged fish within about 10 m of a turbine unit or spillway tainter gate (Figure 3). Underwater antennas were suspended to elevations of 247 ft above mean sea level (MSL) and 227 ft MSL (about 18 and 28 ft deep at normal pool elevation) in the center of the ‘B’ slot of every turbine unit at the powerhouse. Underwater antennas were also placed on the distal end of the main frame supporting each traveling screen in the A, B, and C slots of each turbine. At the spillway, four underwater antennas were used to monitor passage at each spill bay. Two antennas were installed along the pier noses on each side of a spill bay at elevations of 227 and 247 ft MSL; each antenna was pointed toward the center of the spill bay. Within the JBS, antennas (coaxial cables with the distal 23 cm of shielding removed) were installed 20 to 40 ft above and below the primary dewaterer, in the flume leading into the smolt monitoring facility sampling tank, and in the JBS outfall. The inputs from all underwater antennas were monitored by a single Multiprotocol Integrated Telemetry Acquisition System (MITAS; Grant Systems Engineering, King City, Ontario, Canada), which is a PC-based telemetry data collection system.

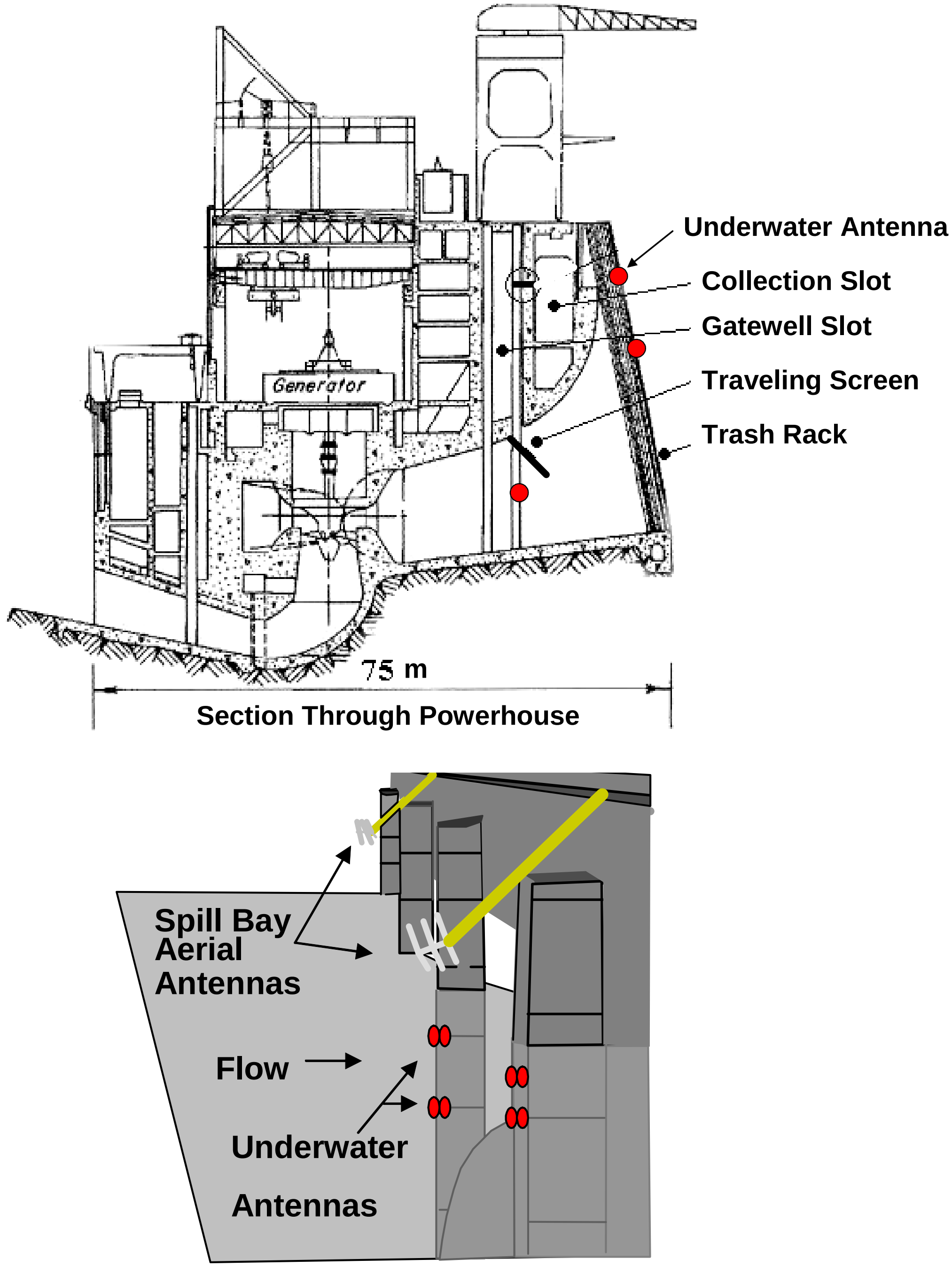

Figure 3. Location of underwater antennas in the middle of the B slot of turbine units 1 through 16 and below the traveling screens in the A, B, and C slots of each unit (upper plate), and the location of aerial and underwater antennas on spill bay piernoses (lower plate) at John Day Dam, 2003. Each aerial antenna covered two spill bays.

Data Management and Analysis

Data from radio-telemetry receivers and the MITAS system were downloaded every day and imported into SAS System for Windows (version 8.1; SAS 2000) to be proofed and analyzed. These data were merged with release information for each radio-tagged fish and electronically proofed using a SAS program created to filter out background noise. Data records were considered to be noise if they met any of the following criteria: 1) they were composed of invalid channel and code combinations, 2) logged before a fish's release, 3) below an empirically determined signal strength threshold for each aerial and underwater, and 4) there were fewer than two records within a 20 min period for an individual fish. Portions of individual fish histories in which there were fewer than 5 records in a 60-min interval on the MITAS underwater antenna array or a single aerial receiver unsupported by at least one record on the corresponding forebay aerial or underwater array during the same hour, or a minimum of two other records at the entrance, JBS, tailrace, and exit stations during the hour interval before and after detection were also designated as noise. The program output was validated against manually proofed radio-telemetry data from similar studies at JDA in 2002 and a subset of the fish releases from the current study.

First entrance time, first and last bypass times, first and last forebay locations and times, first underwater antenna location and time, first and last tailrace locations and times, and first and last exit station times were assigned after the data sets were filtered for background noise. The antenna type and signal strength were used to assign first and last locations in the forebay because of overlapping areas of detection among underwater and aerial antenna arrays. During the first 90 sec of forebay detection, a fish's time and area of first location was assigned to the first underwater antenna detection when present. In the event of simultaneous detections on two adjacent underwater antennas, fish were assigned to a single location corresponding to the antenna with the highest recorded signal strength. Fish not detected on underwater antennas during the first 90 sec, were assigned first forebay times and locations derived from the auxiliary antenna record having the highest signal strength during that period, or the master antenna record with the strongest signal strength if there were no auxiliary antenna records. Similarly, a fish's last forebay location and time were assigned based on antenna type and signal strength during the last 90 sec of a fish's detection history. In order of preference, last location and time was determined from the last underwater detection, auxiliary aerial antenna with the highest signal strength, or master antenna record with the highest signal strength during the last 90 sec of a fish's forebay records. A 90-sec interval was chosen in assigning first and last forebay locations because it coincides with the upper boundary of time needed to complete a receiver scan cycle if several fish are present at the same time.

A radio-tagged fish's time of first detection on near-dam forebay aerial or underwater antennas was considered the time of arrival at JDA. A fish's approach to the dam was defined as its first location within 10 m of the dam as determined from the underwater antenna array. Manual tracking on the dams has verified that the last detection by telemetry receiving equipment is typically a good estimate of a fish's passage route (Sheer et al. 1997; Holmberg et al. 1998; Hensleigh et al. 1999). Hence, the location and time of the last detection of an individual fish on the telemetry equipment on the dam face was considered the route and time of passage through the dam. Fish detected in the JBS were considered to have passed at the powerhouse, but via the JBS non-turbine route.

Forebay residence time was defined as the amount of time between the first and last near-dam detection. These residence times are minimum estimates of the actual time that radio-tagged fish spent in the near-dam area due to the chance that a fish might have been in the near-dam area for an unknown amount of time prior to their first detection and following their last detection. Residence times at the JBS, tailrace, and exit station were calculated similarly. Entrance residence time, a metric not used in past studies, was defined as the time between a fish's first detection at the upriver entrance station and the last near-dam detection. Thus, as calculated, entrance residence time included the time between first entrance and first forebay detection plus forebay residence time.

Once all times and locations of interest (events) were electronically assigned, individual fish histories were verified using criteria derived from manually-proofed radio-telemetry data obtained in 2002 for the same species. A fish's event history was considered potentially suspect if 1) the travel time between release and first forebay, tailrace, or exit detection, or travel time between sequential events was less than the 5^{th} or greater than the 95^{th} percentiles of the 2002 data, 2) forebay, juvenile fish bypass, tailrace, and exit residence times exceeded the 95^{th} percentile of similar 2002 metrics, or 3) a fish's events were chronologically out of order. Fish whose event histories were suspect because of one or more of the above criteria were manually proofed and reconciled with the electronic proof prior to further analyses.

Before comparing the treatments, diel fish detection probabilities at the powerhouse, spillway, and JBS were calculated for each treatment and used to adjust the number of fish detected passing JDA via each passage route. The detection probability of the telemetry arrays at the powerhouse and spillway were calculated using a "double array" methodology as described by Lowther and Skalski (1997). This method is based on the number of fish detected and undetected at each of two arrays to determine the detection probability of each array, and ultimately, the combination of the two arrays. In a double-array system, the detection probability of one array is calculated as:

$$P1 = 11/(11+01) \qquad \text{Equation 1}$$

where 11 denotes fish that were detected on both arrays and 01 denotes those not detected on the first array, but detected on the second. The detection probability of the second array is calculated as:

$$P2 = 11/(11+10) \qquad \text{Equation 2}$$

where 10 denotes those detected on the first array, but not the second. The overall detection probability of the combined arrays is calculated as:

$$P12 = 1-((1-P1)(1-P2)) \qquad \text{Equation 3.}$$

The forebay aerial and underwater arrays at the powerhouse and spillway were considered a single upstream array (P1) for these passage routes and the aerial antennas in the tailrace of each area were considered the downstream arrays (P2). The two arrays in the JBS were composed of underwater antennas above and below the primary dewaterer (P1 and P2, respectively).

Total numbers of fish detected passing via the spillway, powerhouse, or JBS were adjusted by dividing the numbers detected passing at each of these routes by the detection probability for that route (P12). For example, the adjusted number of fish passing through the powerhouse during the day or night for a particular treatment was calculated as:

$$PH_{adj} = PH_{det} / PH_{P12}$$

where PH_{adj} and PH_{det} are the adjusted and detected numbers of fish passing the powerhouse, and PH_{P12} is the detection probability at the powerhouse.

Fish passage efficiency (FPE) was determined as the proportion of the total number of radio-tagged yearling or subyearling Chinook salmon exiting the near-dam forebay that passed via non-turbine routes (i.e., through the spillway or the JBS) multiplied by 100%. Similarly, spill passage efficiency (SPE) and juvenile fish bypass efficiency (JBYPE) was calculated as the proportion of the total number of radio-tagged yearling or subyearling Chinook salmon passing the dam via the spillway or JBS, respectively, multiplied by 100%. Spill effectiveness was calculated as the ratio of the proportion of total fish passage through the spillway to the proportion of total discharge spilled.

Passage indices calculated for each treatment and the day and night time periods were compared statistically after adjusting for block effects (if present) using logistic regression. Logistic regression is a form of statistical modeling that can be used to describe the relationship between a dichotomous response variable and a set of explanatory variables (Stokes et al. 2000). Logistic regression estimates the probability of an event (e.g., passing via a non-turbine route) after converting the dependent variable to a logit (the natural log of the event occurring or not). An “odds ratio” is calculated from the odds of the dependent variable occurring in each of the two classes (i.e., day and night passage), and from this, the relative importance of the effects of the independent variables on the dependent variable is estimated. For example, if the hypothetical odds ratio between day and night FPE is 5, the probability of passing via a non-turbine route during the day is 5 times greater than at night. Overdispersion was assessed by examining a model's residual deviance divided by the residual degrees of freedom. When overdispersion was indicated, the standard errors were adjusted or scaled by multiplying by the square root of the ratio of the deviance and the degrees of freedom. Ninety-five percent profile likelihood confidence intervals were calculated for the overall odds ratio and single seasonal estimates of the passage indices for each treatment.

The hour of fish arrival, diel approach patterns, and hour of passage were examined graphically. Diel forebay residence times were compared between and within spill treatments using the Wilcoxon Rank Sum test. Results of statistical tests throughout this report were considered statistically significant when $P < 0.05$.

Results from the Spring Study Period

Dam Operations

The observed mean day and night percent spill levels were similar to those proposed. Mean hourly percent day spill generally ranged from 0 to 1% among blocks, but during blocks 10 and 11 of the 00/45 treatment, was as high as 11 and 4%, respectively (Table 2). The mean hourly percent night spill during the 00/45 treatment varied between 44 and 45%, except during block 10 when it was 42%; whereas the mean percent night spill during the 00/60 treatment ranged between 57 and 60% during blocks 2 through 8 and between 52 and 55% during blocks 9 through 11. The day spill period began at 0700 hour and ended at 1859 hours until 15 May when it was extended and thereafter ended at 1959 hours. The night spill period began at 1900 hours and ended at 0659 hours until 15 May when it was shortened and thereafter began at 2000 hours. Mean project discharge ranged from 181 to 365 thousand cubic feet per second (KCFS) during the study (Table 2 and Figure 4). Water temperature increased during the spring study period, while the forebay elevation remained relatively constant (Figure 5).

Number of Fish Released and Detected

From 27 April through 05 June 2003, 1389 yearling Chinook salmon were radio-tagged and released (Appendix A). Approximately 140 radio-tagged fish were released per block (70 per spill treatment). Released fish had a mean fork length of 155 mm (122 to 220 mm) and a mean weight of 37 g (18 to 118 g). The mean tag weight to body weight ratio was 3.8% (range 1.2 to 7.8%). Radio-tagged yearling Chinook salmon passed JDA between 28 April and 07 June 2003 during the 5th through 98th percentile of the spring out migration (blocks 2 through 11, Figure 6, Appendix B). Fish sampled by the Smolt Monitoring Facility averaged 165 mm in length (85 mm to 296 mm). Ninety-five percent of the fish released were detected at JDA (Appendix A).

Table 2. Mean hourly percentages of total discharge spilled and mean hourly total discharge (KCFS) at John Day Dam, 28 April through 07 June 2003. Proposed spill treatments consisted of one 2-d treatment of no day spill (0700 to 1859 hours or 0700 to 1959 hours) and 60% night spill (1900 to 0659 hours or 2000 to 0659 hours; 00/60 treatment) and a second 2-d treatment of no day spill and 45% night spill (00/45 treatment) randomized within nine 4-d blocks. Std = standard deviation.

		Hourly percent spill					
	Spill	Day			Night		
Block	treatment	Mean	Std	Range	Mean	Std	Range
2	00/45	0	0	0	45	2	41-50
	00/60	0	1	0-4	59	2	55-61
3	00/45	1	2	0-8	44	1	41-47
	00/60	1	2	0-9	59	2	55-62
4	00/45	0	1	0-3	44	1	40-46
	00/60	0	1	0-3	60	2	56-62
5	00/45	0	1	0-6	45	4	40-59
	00/60	1	2	0-7	60	4	53-72
6	00/45	0	1	0-4	44	1	42-46
	00/60	0	1	0-7	57	4	49-61
7	00/45	0	0	0	44	2	40-47
	00/60	0	1	0-4	59	2	55-62
8	00/45	0	1	0-2	44	1	43-47
	00/60	0	0	0-1	57	5	42-63
9	00/45	0	0	0-1	45	4	38-55
	00/60	0	1	0-4	52	8	40-67
10	00/45	11	3	8-17	42	7	13-46
	00/60	1	2	0-10	53	6	44-60
11	00/45	4	5	0-12	45	2	41-49
	00/60	0	0	0-1	55	5	45-61

Table 2. Continued.

Block	Spill treatment	Day Mean	Day Std	Day Range	Night Mean	Night Std	Night Range
		Hourly total discharge					
2	00/45	228	18	194-253	218	38	143-282
	00/60	238	22	199-265	211	15	189-233
3	00/45	201	19	161-240	217	18	169-252
	00/60	196	22	164-235	202	32	165-249
4	00/45	230	29	164-268	230	29	182-258
	00/60	221	33	187-296	224	24	193-265
5	00/45	202	34	134-259	181	23	153-226
	00/60	196	9	181-210	211	33	164-283
6	00/45	215	36	166-287	268	20	239-301
	00/60	230	25	125-291	267	39	204-331
7	00/45	224	16	185-263	218	38	159-266
	00/60	221	27	185-277	225	37	182-286
8	00/45	228	23	204-271	265	31	215-320
	00/60	247	23	200-297	250	44	194-333
9	00/45	262	43	197-303	320	44	233-416
	00/60	308	18	250-329	266	70	147-369
10	00/45	365	11	344-391	337	26	299-391
	00/60	304	22	271-334	296	44	220-360
11	00/45	300	18	273-334	292	56	210-376
	00/60	282	9	250-292	251	49	195-322

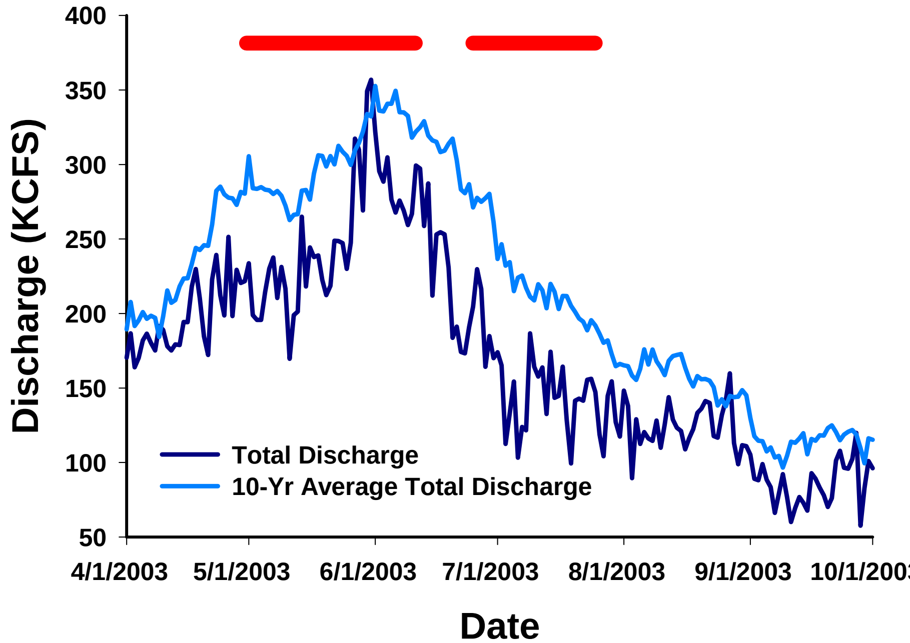

Figure 4. Total project discharge (lower line) in thousand cubic feet per second (KCFS) and the 10-year average total discharge (upper line) at John Day Dam between 01 April and 01 October 2003. Horizontal bars indicate spring and summer release periods. Data from University of Washington at http://www.cqs.washington.edu/dart/river.html.

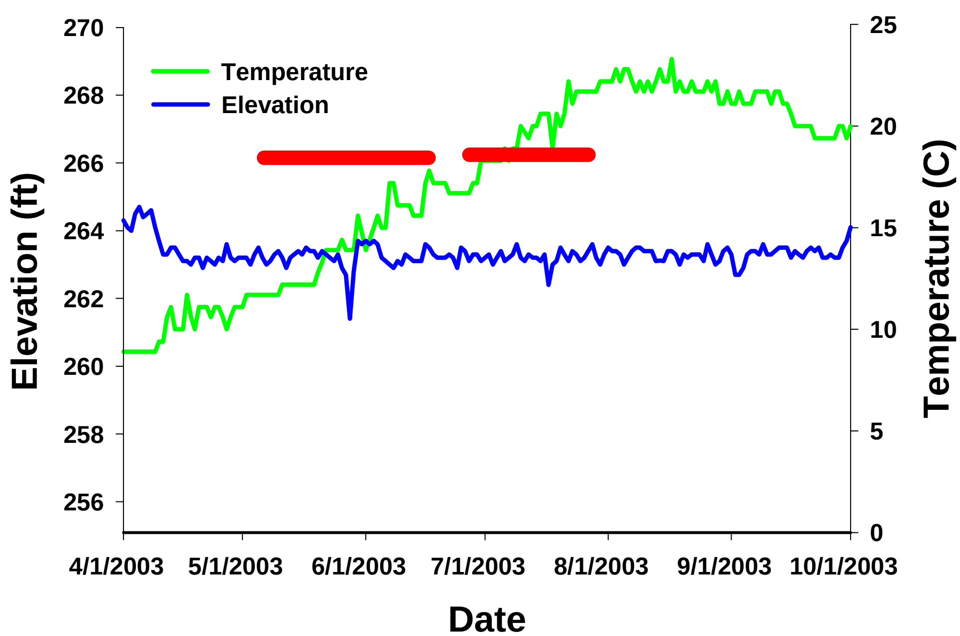

Figure 5. Elevation and water temperature at John Day Dam forebay between 01 April and 01 October 2003. Horizontal bars indicate spring and summer release periods. Data from University of Washington at http://www.cqs.washington.edu/dart/river.html.

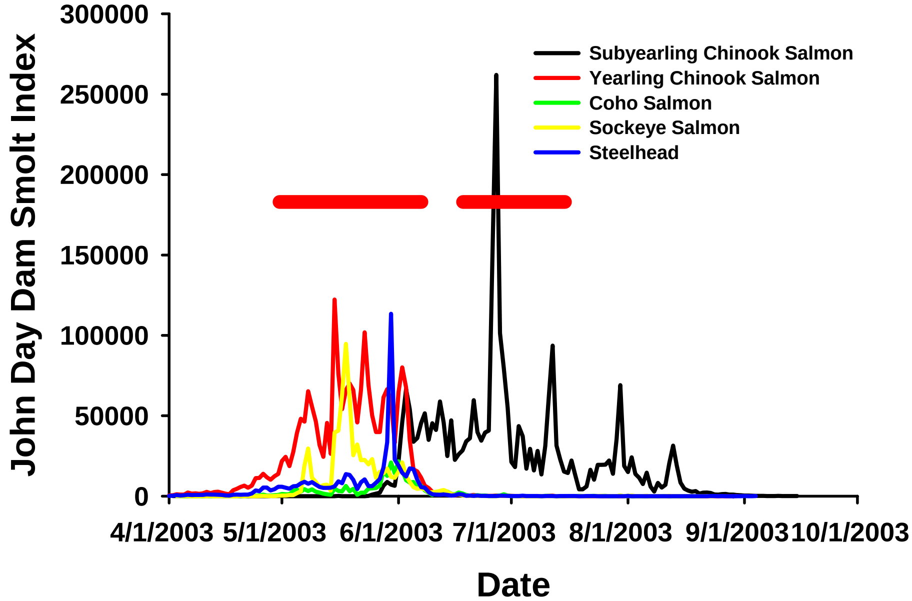

Figure 6. Smolt passage index at John Day Dam between 01 April and 01 October 2003. Horizontal bars indicate spring and summer release periods. Data from University of Washington website at http://www.cqs.washington.edu/dart/river.html.

Travel Time, Arrival Time, and Approach Pattern

Median travel time of yearling Chinook salmon from release at Rock Creek to arrival at the JDA forebay were similar was 19 h. The median travel time of fish released at 0900 hours was 17 h (range 7 to 93 h) and the median travel time of fish released at 2100 hours was 20 h (range 9 to 60 h). The hour of arrival at JDA was dispersed throughout the diel period because of the variability in travel time among individuals (Figure 7). Forty-nine percent of the radio-tagged fish arrived during the day and 51% arrived at night.

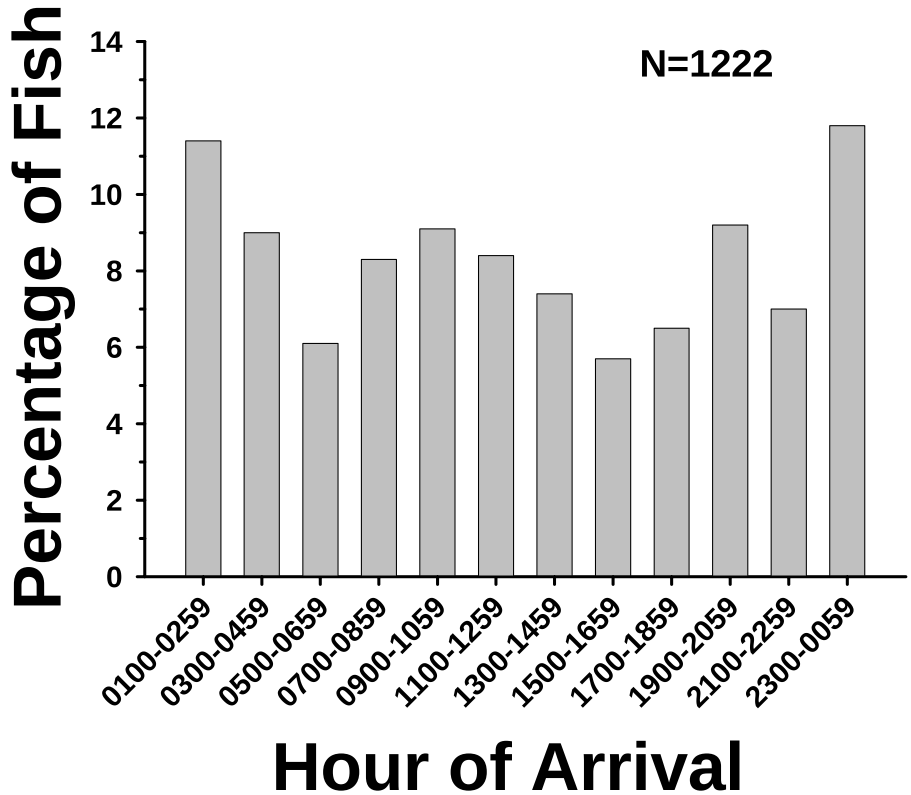

Figure 7. Hour of arrival (2-h intervals) of radio-tagged yearling Chinook salmon within 100 m of John Day Dam, 28 April through 07 June 2003. All fish were released 23 km upriver of the dam near Rock Creek, Washington.

The area of first detection within 10 m of the dam was affected by dam operating conditions. Fish first approached the dam predominantly at the powerhouse during the day and at the spillway during the night (Figure 8). The percentage of first detections at the powerhouse were higher at the south end (units 1 through 8) than the north end, while first detections at the spillway were more equally distributed among spill bays (Figure 9 and Table 3). The distribution of first detections at the powerhouse and spillway reflect the proportion of time that individual turbine units and tainter gates were discharging water during the study period (Appendix C).

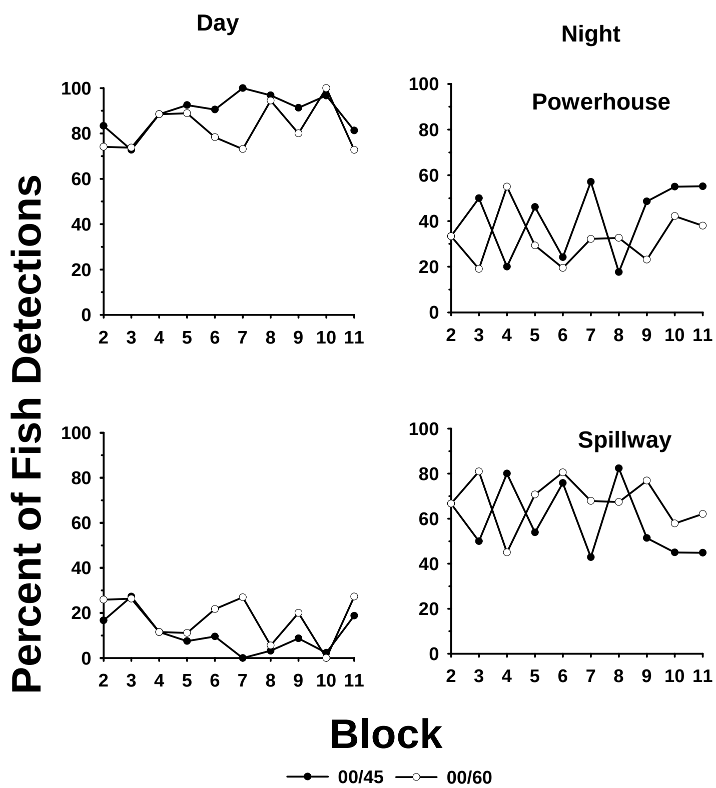

Figure 8. Percentage of radio-tagged yearling Chinook salmon first detected within 10 m of the powerhouse and spillway at John Day Dam, 28 April through 07 June 2003. 00/45 = 0% day spill , 45% night spill and 00/60 = 0% day and 60% night spill. Sample sizes for blocks ranged from 19 to 43 during the day and from 13 to 42 at night.

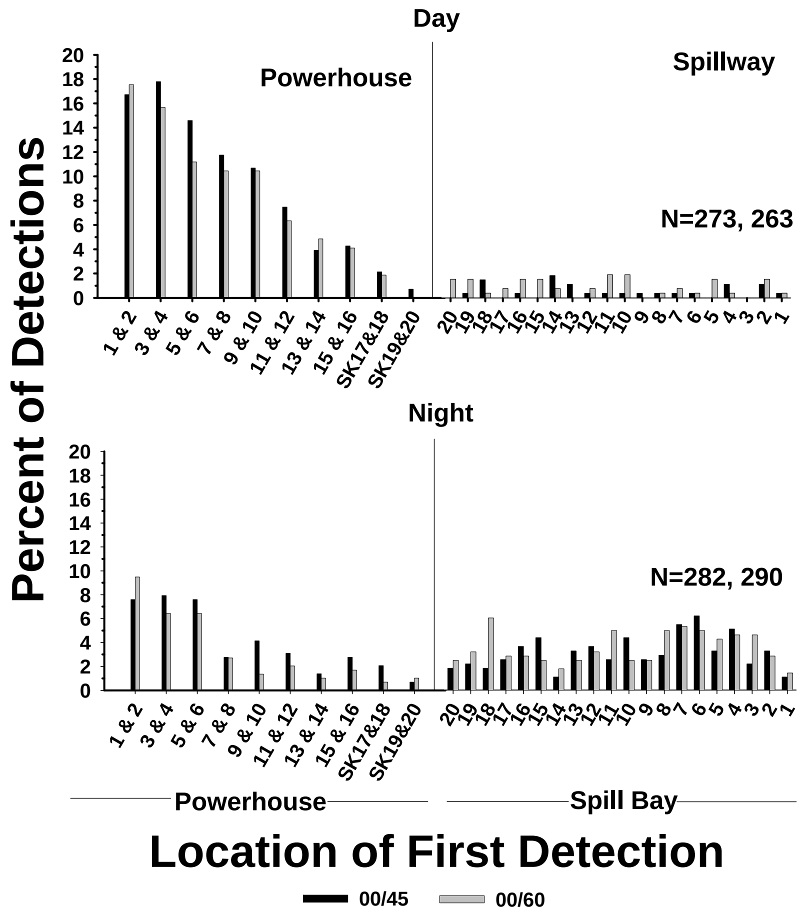

Figure 9. Percent of radio-tagged yearling Chinook salmon first detected on forebay underwater antennas within 10 m of John Day Dam at turbine units 1 through 16 and spillway tainter gates 20 through 1, 28 April through 07 June 2003. Turbine units and spillway tainter gates are graphed from north to south facing downriver. 00/45 = 0% day spill and 45% night spill treatment, 00/60 = 0% day and 60% night spill treatment. N = sample size (00/45, 00/60).

Table 3. Percentage of yearling Chinook salmon first detections by forebay area at John Day Dam, 28 April through 07 June 2003. 00/45 = 0% day spill and 45% night spill treatment, 00/60 = 0% day and 60% night spill treatment.

Forebay area	Diel	00/45 (%)	00/60 (%)
Turbine Units 1-8	Day	61	55
Turbine Units 9-16	Day	26	26
Skeleton Bays 17-20	Day	3	2
Spill Bays 1-20	Day	10	17
Turbine Units 1-8	Night	26	25
Turbine Units 9-16	Night	11	6
Skeleton Bays 17-20	Night	3	2
Spill Bays 1-20	Night	60	67

Residence Times and Time of Passage

Median entrance and forebay residence times at JDA were influenced by the time of arrival (day vs. night) and the associated dam operations at JDA. Median forebay residence times during the day were 10 times longer during the 00/45 treatment and 7 times longer during the 00/60 treatment, than corresponding median residence times at night (Table 4). Median entrance residence times were about 2 times longer during the day than at night. The median difference in time between first detection at upstream entrance antennas and first detection at the forebay antennas was short (0.6 to 0.9 h) regardless of time of arrival and dam operating conditions, indicating that fish generally moved quickly from the entrance station to the forebay. Thus, it seems likely that most of the diel variation in entrance residence time was a result of behavioral responses to forebay conditions rather than conditions as far upstream as the entrance antennas.

Table 4. Twenty-fifth, 50th (median) , and 75th percentiles of radio-tagged yearling Chinook salmon entrance and forebay residence times (h) at John Day Dam by diel period and treatment (Trt) at arrival, 28 April through 07 June 2003. Day and night refer to dam operating periods. 00/45 Trt: 0% day spill and 45% night spill. 00/60 Trt: 0% day spill and 60% night spill. N=sample size.

Diel		Entrance				Forebay			
period	Trt	25th	Median	75th	N	25th	Median	75th	N
Day	00/45	2.8	6.8	16.2	185	1.1	5.2	14.5	306
	00/60	1.3	3.6	9.7	155	0.4	2.8	9.5	305
Night	00/45	1.0	3.7	11.2	182	0.0	0.5	6.3	309
	00/60	1.0	2.2	7.0	175	0.1	0.4	2.7	316

The median forebay residence times of the yearling Chinook salmon ranged from 0.2 to 15.6 h during the 00/45 treatment and from 0.1 to 8.2 h during the 00/60 treatment (Figure 10). Within blocks, forebay residence times were longer during the day than the night for both treatments (Figure 10). These differences were significant in 7 out of 10 blocks during the 00/45 treatment and 8 out of 10 blocks during the 00/60 treatment (Wilcoxon Rank Sum tests, P's < 0.05, df=1). Forebay residence times did not generally differ between treatments within blocks during day or night. During the day, residence times differed significantly between treatments in 3 out of 10 blocks and at night; no significant differences were present (Wilcoxon Rank Sum tests, df = 1).

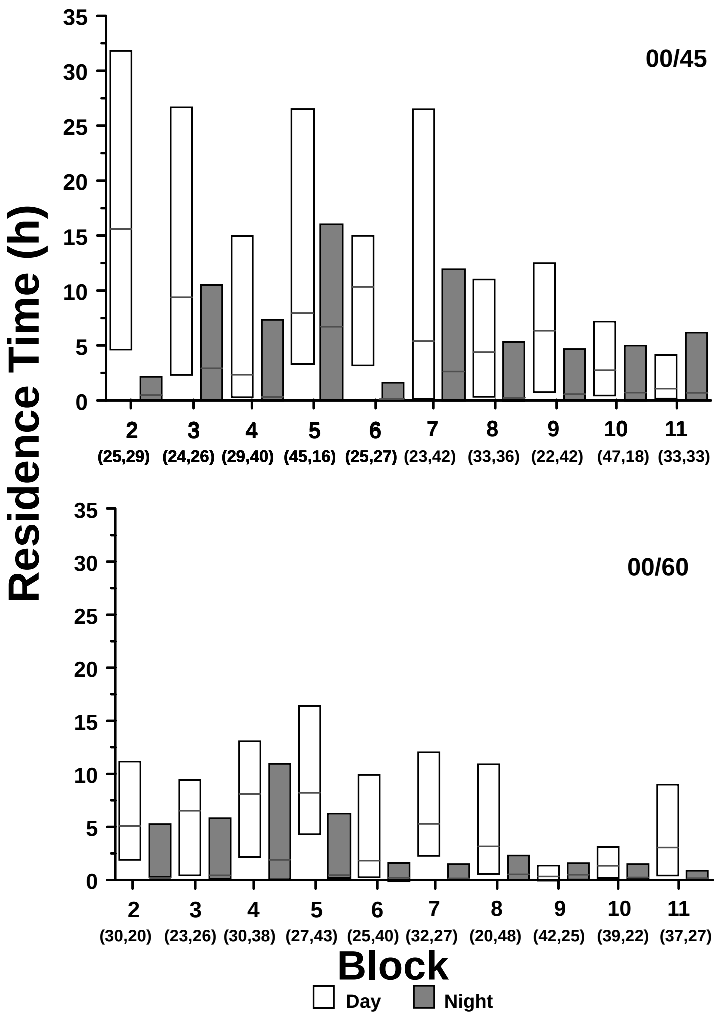

Figure 10. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged yearling Chinook salmon forebay residence times by diel time of arrival at John Day Dam, 28 April through 07 June 2003. Day and night refer to the two diel, 12-h operational spill periods. 00/45 = 0% day spill and 45% night spill, 00/60 = 0% day spill and 60% night spill. Sample sizes are in parentheses (day, night).

Increased variation in residence times during the day of both treatments can be attributed to a fish's time of arrival. Yearling Chinook salmon arriving at JDA shortly after the switch from night to day spill conditions (0700 to 1100 hours) had the longest median forebay residence times (Table 5), whereas fish that arrived shortly before the switch from day to night spill conditions (1500 to 1900 hours) had the shortest median residence times during the day. Fish arriving during night spill passed relatively quickly regardless of when they arrived.

Table 5. Median forebay residence times (h) of radio-tagged yearling Chinook salmon by time of arrival (hours) within diel period and spill treatment at John Day Dam, spring 2003. Day and night refer to dam operating periods. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Sample sizes are shown in parentheses.

Time of arrival	Diel	Spill treatment 00/45	Spill treatment 00/60
0700-1059	Day	7.0(102)	6.2(117)
1100-1459	Day	5.1(106)	3.2 (90)
1500-1859	Day	3.2 (80)	2.5 (69)
1900-2259	Night	2.0 (95)	0.5(105)
2300-0259	Night	0.1(149)	0.2(138)
0300-0559	Night	1.7 (83)	0.7(102)

The time of day that radio-tagged fish passed JDA was affected by release times, individual travel times from the release site, and behavioral responses to dam operations at the time of arrival (Figure 11). Most yearling Chinook salmon passed at night, even though fish arrival was equally distributed between the day and night, because of longer forebay residence times during the day. Only 49% of the fish that arrived during the day passed during the day conditions, whereas 85% of the fish arriving at night passed during the night. As a result, 32% of the radio-tagged fish passed the dam during the day and 68% passed at night.

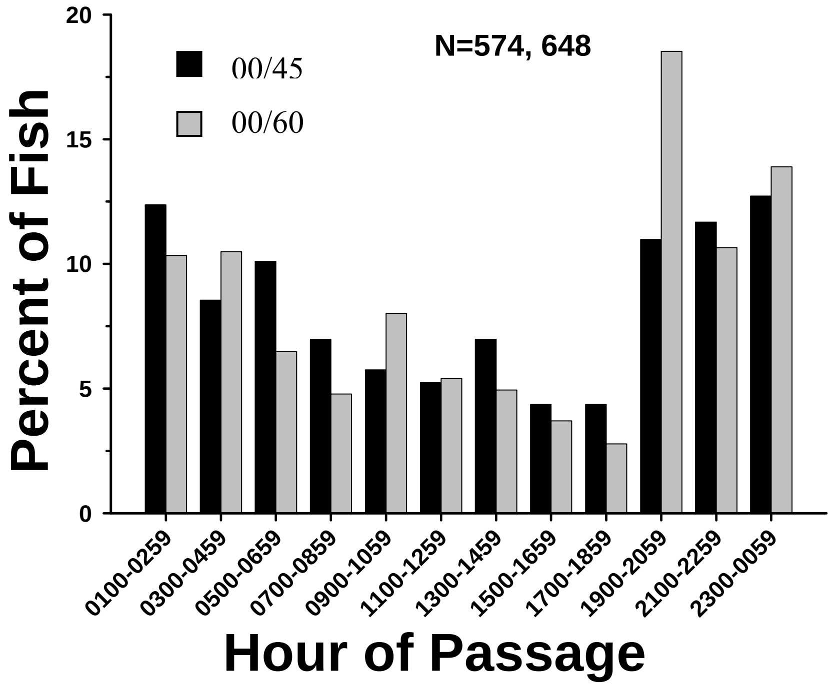

Figure 11. Hour of passage (2-h intervals) of radio-tagged yearling Chinook salmon at John Day Dam, 28 April through 07 June 2003. All fish were released 23 km upriver of the dam near Rock Creek, Washington. 00/45 = 0% day spill and 45% night spill, 00/60 = 0% day spill and 60% night spill. Sample sizes are in parentheses (00/45, 00/60).

Diel Detection Probabilities and General Route of Passage

Detection probabilities were high for all passage routes and had no effect on observed frequencies of fish estimated to pass JDA via the three major passage routes. Detection probabilities at the spillway and JBS were greater than 0.99 regardless of diel period or treatment and those at the powerhouse ranged from 0.97 to 1.00 (Table 6).

Diel differences in the proportion of radio-tagged yearling Chinook salmon passing via the major passage routes were evident. Most fish passed through the JBS during the day, whereas most fish passed via the spillway at night (Figure 12).

Table 6. Yearling Chinook salmon diel capture histories and detection probabilities at telemetry arrays at the John Day Dam powerhouse, spillway, and juvenile fish bypass system (JBS), spring 2003. Capture history "10" = number of fish detected only on array 1, "01" = number of fish detected only on telemetry array 2, and "11" = number of fish detected on both array 1 and 2. P1 = probability of detection on array 1. P2 = probability of detection on array 2. P12 = probability of detection for array 1 and 2 combined.

Capture	Day						Night					
History	Powerhouse		Spillway		JBS		Powerhouse		Spillway		JBS	
	00/45	00/60	00/45	00/60	00/45	00/60	00/45	00/60	00/45	00/60	00/45	00/60
10	22	13	0	0	0	1	8	9	45	0	0	0
01	1	0	0	0	13	11	6	3	5	6	6	6
11	19	38	3	1	104	111	43	35	234	92	74	74
Total	42	51	3	0	117	123	57	47	284	98	80	80
	Detection Probabilities											
P1	0.95	1.00	1.00	1.00	0.89	0.91	0.88	0.92	0.98	0.98	0.94	0.93
P2	0.46	0.75	1.00	1.00	1.00	0.99	0.84	0.80	0.84	0.81	1.00	1.00
P12	0.97	1.00	1.00	1.00	1.00	>0.99	0.98	0.98	>0.99	>0.99	1.00	1.00

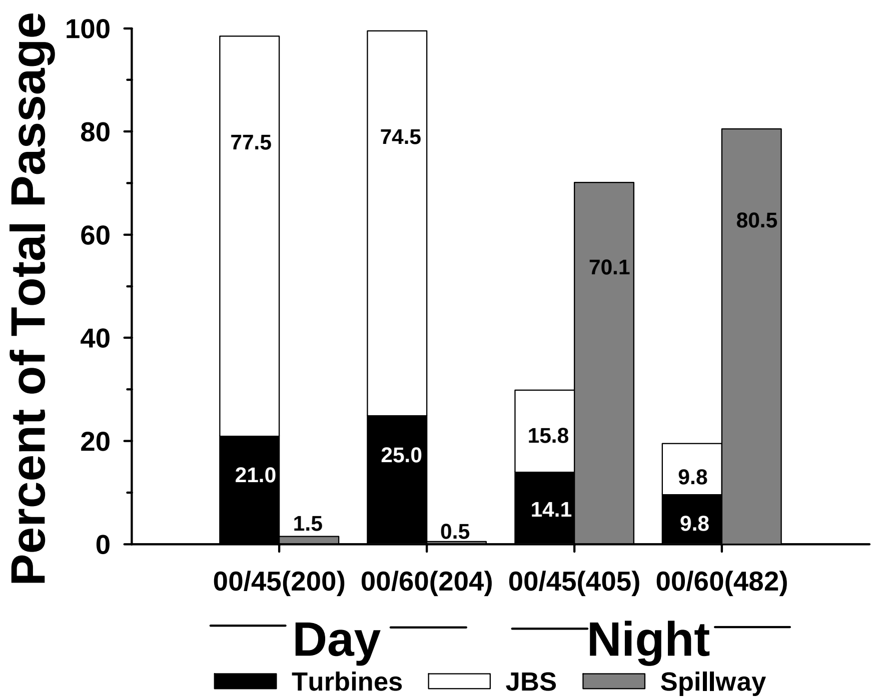

Figure 12. Radio-tagged yearling Chinook salmon passage via the turbines, juvenile fish bypass system (JBS), and spillway at John Day Dam, 28 April through 07 June 2003. Day and night refer to 12-h operational spill periods. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Sample sizes are in parentheses. Actual percent passage is on bars.

Most radio-tagged fish passing JDA at the powerhouse did so at the south end, while passage at the spillway was more equally distributed across spill bays. Of the fish passing via the turbines, about 82% passing during the day, 72% passing during 45% night spill, and 90% passing during 60% night spill, passed through turbine units 1 through 8 (Figure 13).

At the spillway, during 45 % spill 58% of the yearling Chinook salmon passed via spill bays 1 through 10 and 42% passed through bays 11 through 20 (Figure 14). During 60% spill, fish passage was similar between bays 1 through 10 and 11 through 20. Both powerhouse and spillway passage patterns reflect the proportion of time that individual turbine units and tainter gates were operating during the study period (Appendices C and D).

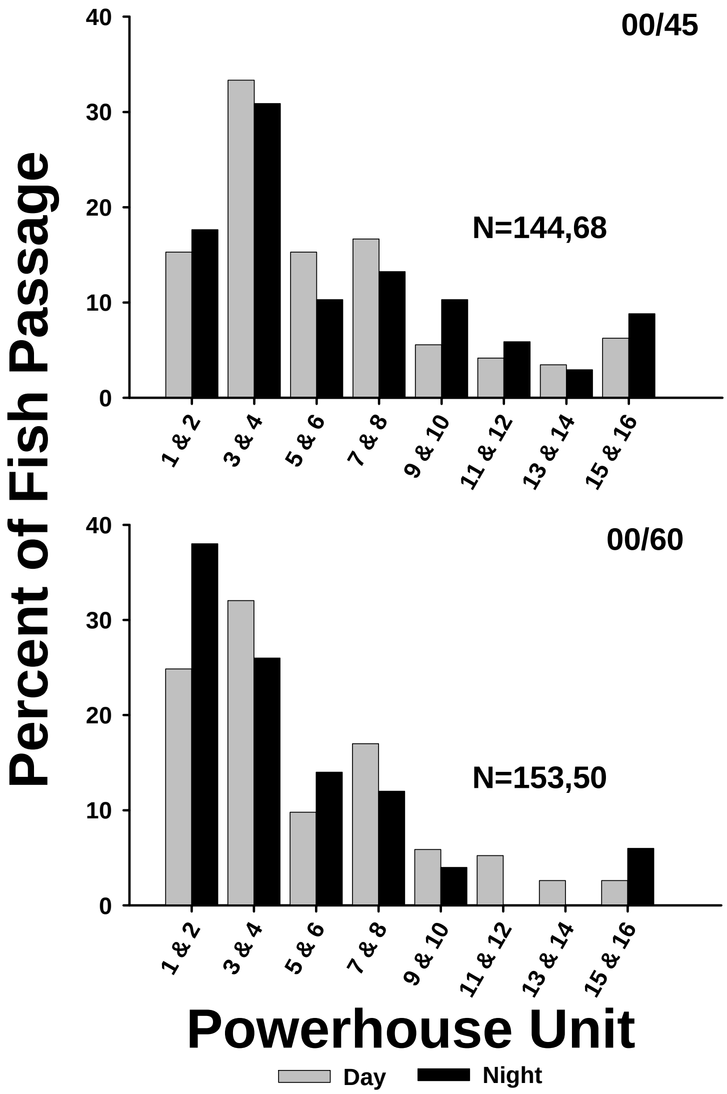

Figure 13. Distribution of radio-tagged yearling Chinook salmon passage via turbine units 1 through 16, John Day Dam, 28 April through 07 June 2003. Day and night refer to 12-h operational spill periods. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Percents are based on underwater antenna detections only. N = day, night.

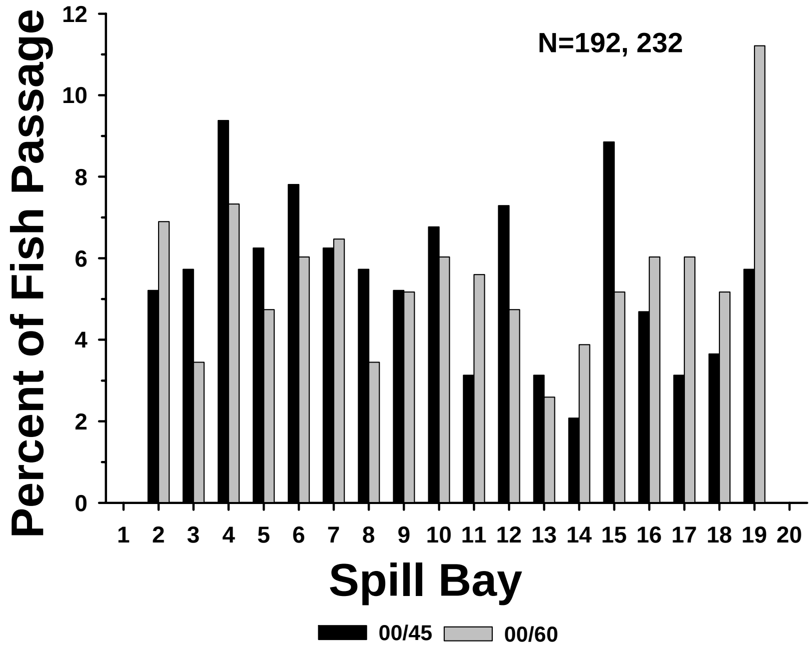

Figure 14. Distribution of radio-tagged yearling Chinook salmon passage via spillway tainter gates 1 through 20, John Day Dam, 28 April through 07 June 2003. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Percents are based on underwater antenna detections only. N = 00/45, 00/60.

Fish-, Spill-, and Juvenile Fish Bypass-Passage Efficiencies

No significant differences in yearling Chinook salmon FPE, SPE, or JBYPE (diel periods pooled) were detected between spill treatments (Figure 15 and Appendix E; Chi-square tests, P = 0.33, 0.06, and 0.13, df = 1). Point estimates of FPE for the 00/45 and 00/60 treatment were 84 and 86%; estimates of SPE were 47 and 57%, and; estimates of JBYPE were 36 and 29% (Table 7).

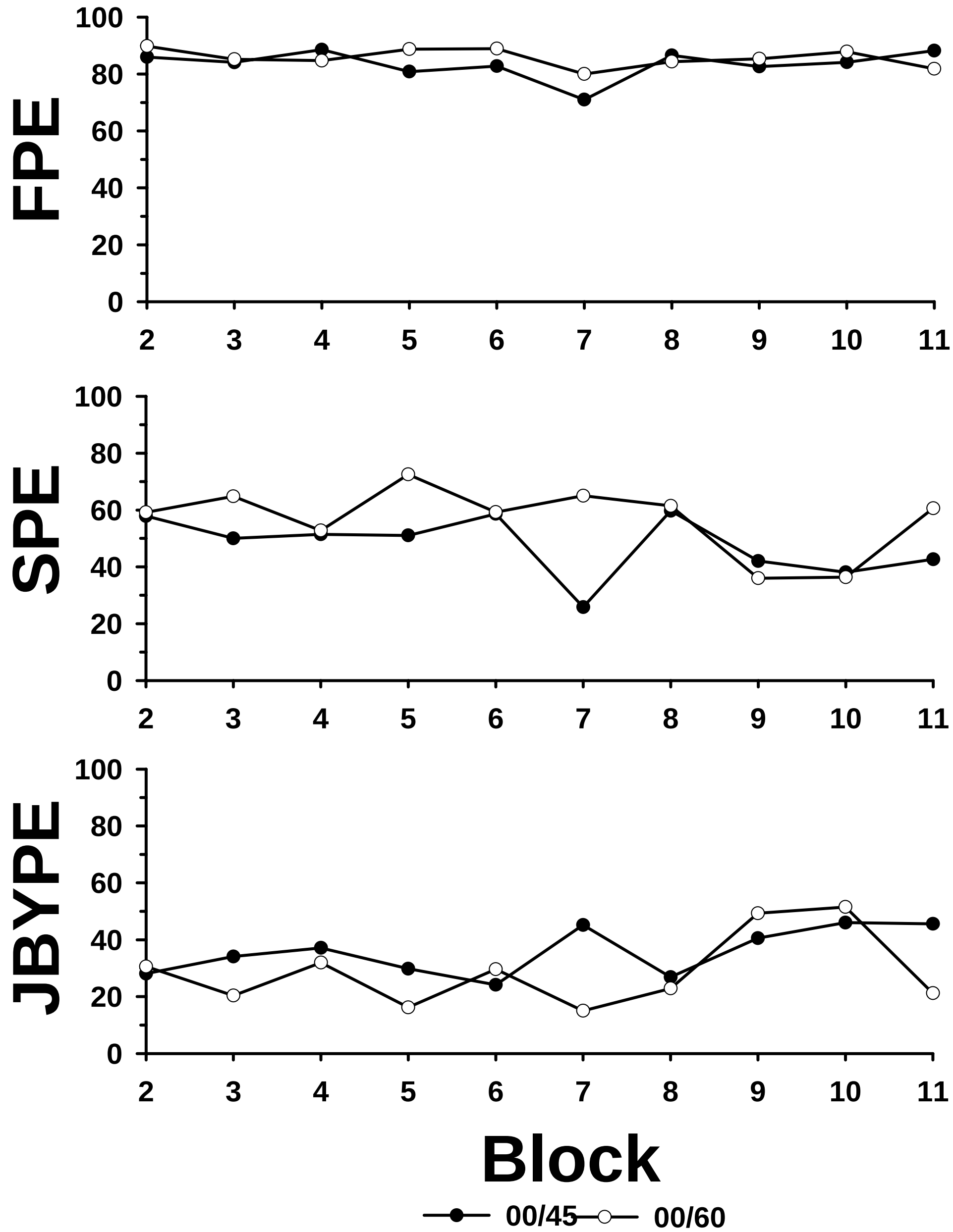

Figure 15. Overall radio-tagged yearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile bypass passage efficiency (JBYPE) by block, John Day Dam, 28 April through 07 June 2003. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Sample sizes are given in Table 7.

Table 7. Pooled and diel passage estimates (Est) of yearling Chinook salmon during 00/45 and 00/60 spill treatments at John Day Dam, spring 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI= likelihood ratio confidence interval. * = significant treatment effect at $\alpha = 0.05$ level.

Diel period	Passage efficiency	00/45 Est	00/45 95% LCRI	00/45 N	00/60 Est	00/60 95%LCRI	00/60 N
Pooled	FPE	83.6	80.6-86.4	686	85.7	83.0-88.2	605
	SPE	47.4	40.0-54.9	686	56.7	49.7-63.6	605
	JBYPE	36.2	29.2-43.6	686	29.0	22.9-35.7	605
Day	FPE[1]	79.0	73.0-84.3	204	75.0	68.8-80.6	200
	SPE	-	-	-	-	-	-
	JBYPE	77.5	71.4-82.9	204	74.5	68.3-80.2	200
Night	FPE	85.9	80.3-90.5	482	90.2	85.8-93.8	405
	SPE *	70.1	62.4-77.2	482	80.5	74.2-85.9	405
	JBYPE *	15.8	11.9-20.3	482	9.7	6.9-13.2	405

[1]: FPE was not exactly equal to JBYPE during the no-spill period due to small amounts of spill and fish passage via the spillway during block 10.

Neither day nor night FPE nor day JBYPE differed significantly between treatments (Chi-square, $P > 0.05$, df = 1), but SPE and JBYPE both differed significantly between treatments at night (Figure 15 and Appendices F-H. Day FPE and JBYPE were not always equal because of small amounts of spill and spillway passage. At night, SPE was significantly greater during 60% spill than 45% spill (Chi-square, $P < 0.04$, df = 1), while JBYPE was significantly less at 60% spill than 45% spill (Chi-square, $P < 0.03$, df = 1). Diel point estimates of FPE, SPE, and JBYPE are given in Table 7.

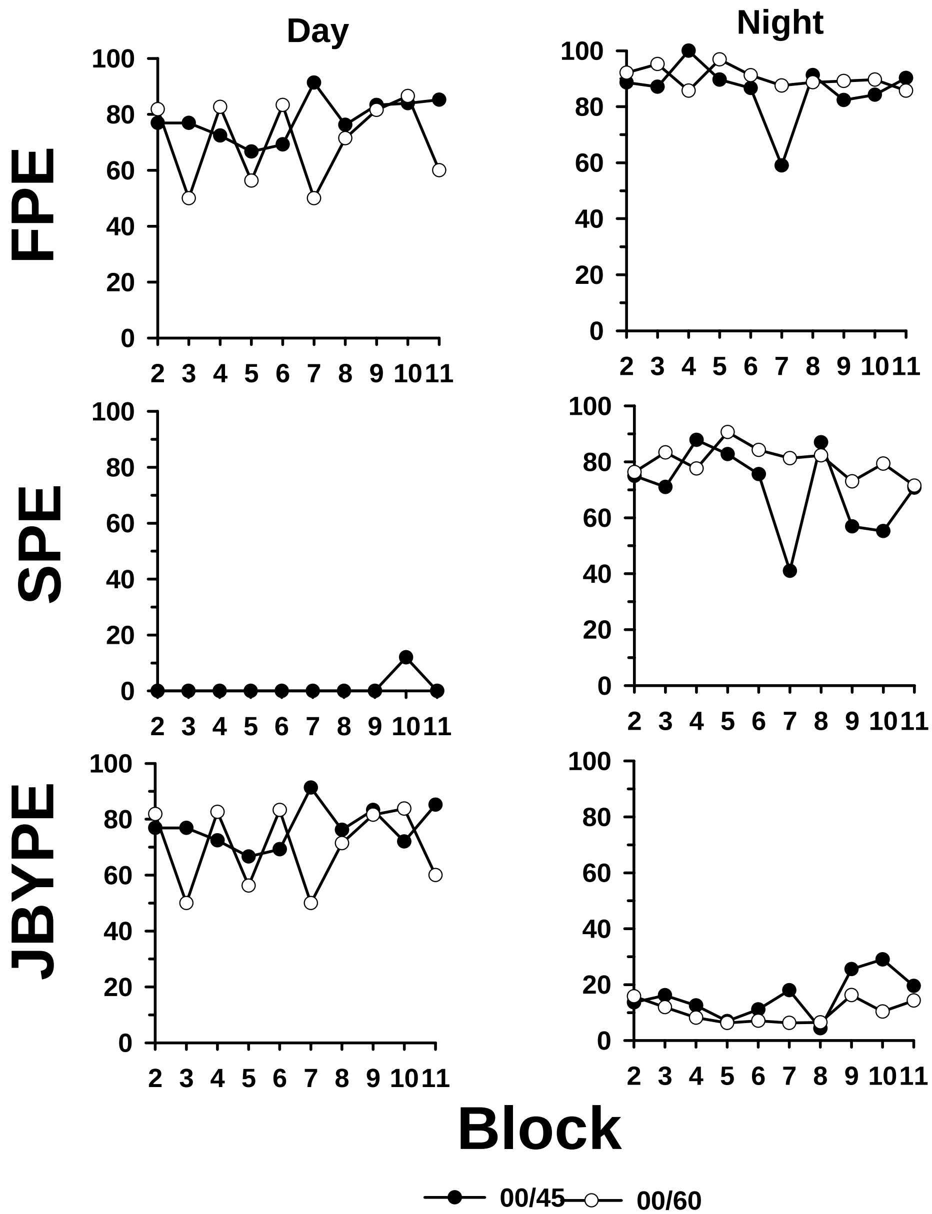

Figure 14. Diel estimates of radio-tagged yearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass passage efficiency (JBYPE) by block, John Day Dam, 28 April through 07 June 2003. 00/45 = 0% day spill and 45% night spill. 00/60 = 0% day spill and 60% night spill. Sample sizes are given in Appendices F-H.

Although SPE at night was significantly greater during 60% spill than 45% spill, the 45% spill was more effective at passing fish through the spillway per volume of water spilled. The spill effectiveness of the 45% spill was 1.6 and the spill effectiveness of 60% spill was 1.3.

Results from the Summer Study Period

Dam Operations

The observed mean day and night percent spill levels were similar to those proposed for the 12- and 24-h spill treatments during the seven blocks of study. Day spill averaged 0% during the 12-h treatment and 29% during the 24-h spill treatment (Table 8). The mean night spill was 56% during the 12-h treatment and 29% during the 24-h treatment. Only the mean night spill during block 7 of the 12-h treatment (44%) deviated substantially from the proposed treatment levels. Mean project discharge ranged from 110 to 224 KCFS during the study (Figure 4, page 20). Water temperature increased during the summer study, while the forebay elevation remained relatively constant (Figure 5, page 20).

Number of Fish Released and Detected

From 22 June through 19 July 2003, 4122 subyearling Chinook salmon were radio-tagged and released (Appendix I). Approximately 540 fish were released per block (270 per spill treatment). Released fish had a mean fork length of 117 mm (range 109 to 153 mm) and a mean weight of 17 g (range 12 to 40 g). The mean tag weight to body weight ratio was 5.0% (range 2.1 to 7.1%). Radio-tagged subyearling Chinook salmon passed JDA between 25 June and 23 July 2003 during the 32nd to 82nd percentile of the summer out migration (blocks 5 through 11; Figure 4 on page 20). Fish sampled by the

Smolt Monitoring Facility averaged 106 mm in length (range 69 mm to 166 mm). Eighty-two percent of these fish were detected at JDA (Appendix I).

Travel Time, Arrival Time, and Approach Pattern

Radio-tagged subyearling Chinook salmon released at approximately 0900 hours had significantly faster travel times to the JDA forebay than fish released at 2100 hours (median 22 vs. 32 h; Wilcoxon Rank Sum test, $P < 0.0001$, df = 1). The pooled median travel time was 25 h (range 12 to 49 h). Because of the variability in travel times among individuals, the hour of arrival at JDA was dispersed throughout the diel period (Figure 17). Fish arrival peaked slightly between 0500 and 1100 hours; 55% of the fish arrived during the day and 45% arrived at night. The first detection of subyearling Chinook salmon, within 10 m of the dam, was influenced by the percentage of river flow discharged through the powerhouse and spillway. During the 12-h treatment, most fish were first detected at the powerhouse during the day and at the spillway at night; whereas during the 24-h treatment, about equal percentages of radio-tagged fish were first detected at the powerhouse and spillway during the day and the night (Figure 18). During spill, most first detections at the powerhouse were at the south end (turbine units 1 through 8), while most spillway first detections were at the north end of the spillway (spill bays 1 through 10; Figure 19 and Table 9). Powerhouse and spillway first detections were both more equally distributed across the powerhouse and spillway when there was no spill. Both the day and night distributions of first detections during

Table 8. Mean hourly percentages of total discharge spilled and mean hourly total discharge (KCFS) at John Day Dam, 25 June through 23 July 2003. Proposed spill treatments consisted of one 2-d treatment of no day spill (0700 to 1859 or 0700 to 1959 hours) and 60% night spill (1900 to 0659 hours or 2000 to 0659 hours; 12-h treatment) and a second 2-d treatment of 30% day spill and 30% night spill (24-h treatment) randomized with seven 4-d blocks. Std = standard deviation.

		Hourly percent spill					
	Spill	Day			Night		
Block	treatment	Mean	Std	Range	Mean	Std	Range
5	12-h	0	1	0-3	57	3	49-61
	24-h	30	1	28-31	30	1	29-33
6	12-h	0	1	0-5	59	2	54-62
	24-h	29	1	27-31	29	1	27-33
7	12-h	0	0	0-1	44	14	24-61
	24-h	28	6	2-30	29	1	26-31
8	12-h	0	1	0-3	59	2	54-60
	24-h	28	5	2-30	29	1	26-31
9	12-h	0	1	0-6	59	2	56-62
	24-h	30	1	29-31	30	1	26-31
10	12-h	0	0	0	56	4	47-62
	24-h	29	1	28-30	29	1	26-32
11	12-h	0	1	0-4	57	4	48-62
	24-h	29	1	28-31	30	1	29-33

Table 8. Continued.

Block	Spill treatment	Hourly total discharge: Day Mean	Day Std	Day Range	Night Mean	Night Std	Night Range
5	12-h	224	40	153-314	211	68	121-336
	24-h	198	52	107-301	191	63	100-326
6	12-h	182	12	156-202	156	37	127-240
	24-h	179	18	146-211	163	37	102-225
7	12-h	128	26	66-162	112	39	71-181
	24-h	110	21	91-152	143	14	112-166
8	12-h	117	18	92-151	152	25	102-198
	24-h	186	26	129-228	156	38	96-214
9	12-h	165	12	133-183	157	21	122-188
	24-h	154	32	102-203	141	38	81-215
10	12-h	159	30	114-204	137	23	108-191
	24-h	145	26	116-188	133	48	74-246
11	12-h	150	15	122-168	137	23	102-176
	24-h	122	30	77-159	123	18	97-157

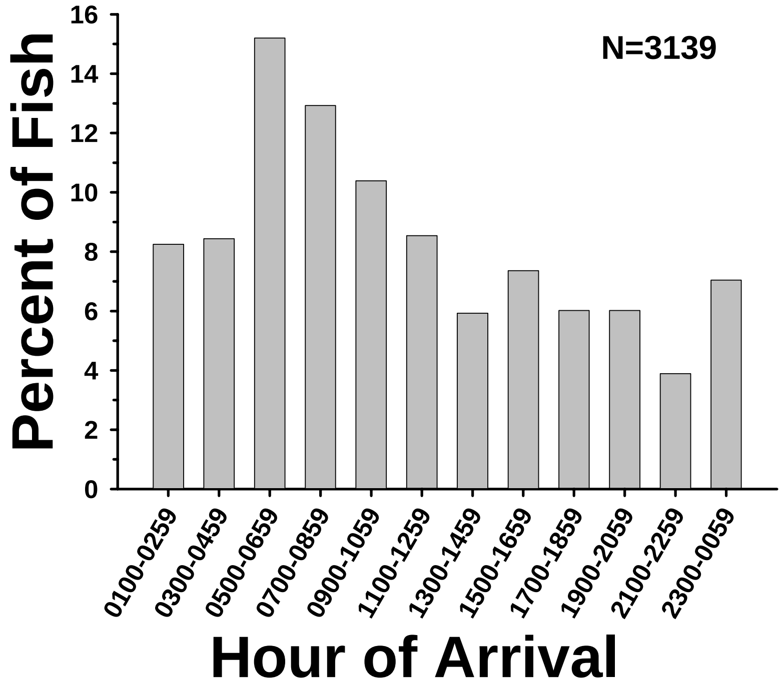

Figure 17. Hour of arrival (2-h intervals) of radio-tagged subyearling Chinook salmon within 100 m of John Day Dam, 25 June through 23 July 2003. All fish were released 23 km upriver of the dam near Rock Creek, Washington. N = sample size.

the 12- and 24-h spill treatments reflect the proportion of time that individual turbine units and tainter gates were discharging water during the study period (Appendices F and G).

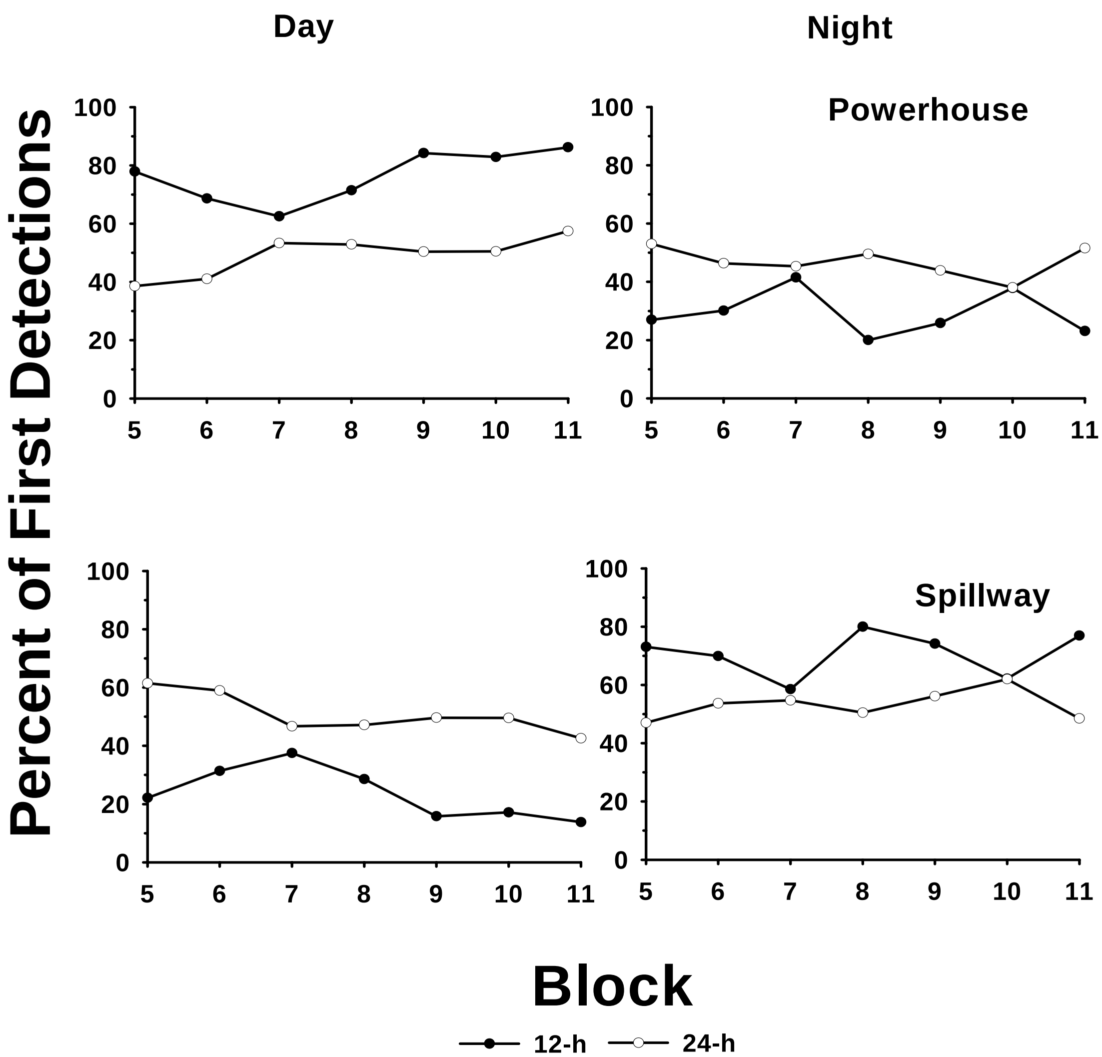

Figure 18. Percentage of radio-tagged subyearling Chinook salmon first detected at the powerhouse and spillway during 12 and 24-h spill treatments at John Day Dam, summer 2003. Blocks are 4-d intervals comprised of two 2-d treatments from 25 June through 23 July. Sample sizes for blocks ranged from 29 to 147 during the day and from 26 to 141 at night.

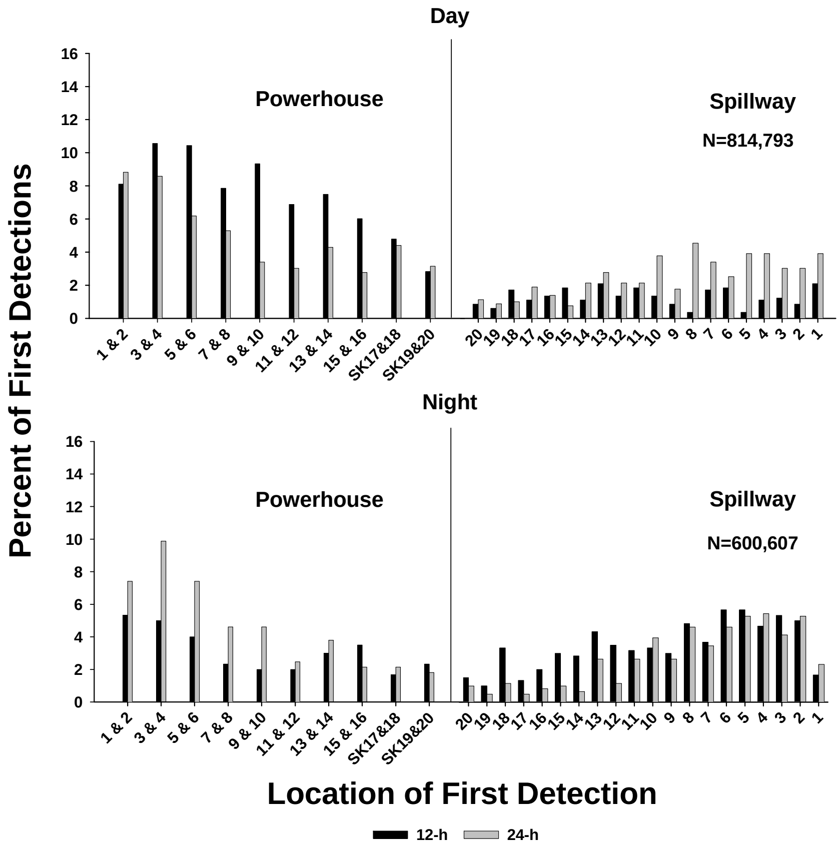

Figure 19. Percent of radio-tagged subyearling Chinook salmon first detected on forebay underwater antennas within 10 m of John Day Dam at turbine units 1 through 16, skeleton bays 17 through 20, and spill bays 20 through 1, 25 June through 23 July 2003. Locations are graphed from north and south facing downriver. 12-h = 0% day spill and 60% night spill, 24-h = 30% day and night spill. N = sample size (12-h, 24-h).

Table 9. Percentage of subyearling Chinook salmon first detections by forebay area at John Day Dam, 25 June through 23 July 2003. 12-h = 0% day spill and 60% night spill, 24-h = 30% day and night spill.

Forebay area	Diel	12-h (%)	24-h (%)
Turbine Units 1-8	Day	37	29
Turbine Units 9-16	Day	30	13
Skeleton Bays 17-20	Day	7	8
Spill Bays 11-20	Day	14	16
Spill Bays 1-10	Day	12	34
Turbine Units 1-8	Night	17	29
Turbine Units 9-16	Night	10	13
Skeleton Bays 17-20	Night	4	4
Spill Bays 11-20	Night	26	12
Spill Bays 1-10	Night	43	42

Residence Times and Time of Passage

Overall median entrance and forebay residence times were both longer when there was no spill than when there was spill at the time of arrival at JDA (Table 10). Median entrance residence times were 1.8 to 3.6 h longer than forebay residence times. The median difference in time between first detection at upriver entrance antennas and first detection at forebay antennas was relatively similar across spill conditions (0.8 to 1.1 h) indicating radio-tagged fish generally moved quickly from the entrance station to the forebay. Thus, it seems likely that most of the observed variation in entrance residence time between spill and no spill periods was caused by behavioral responses of fish within 100 m of JDA rather than as far upstream as the entrance antennas (600 m).

Table 10. Twenty-fifth, 50th (median), and 75th percentiles of radio-tagged yearling Chinook salmon entrance and forebay residence times (h) at John Day Dam by diel period and treatment (Trt) at arrival, 25 June through 23 July 2003. Residence times were calculated from first entrance or forebay time to last forebay time. Day and night refer diel 12-h operating periods. 12-h Trt: 0% day spill and 60% night spill. 24-h Trt: 30% day and night spill. N = sample size.

Diel		Entrance				Forebay			
period	Trt	25th	Median	75th	N	25th	Median	75th	N
Day	12-h	2.5	6.6	18.4	466	0.7	3.8	12.6	737
	24-h	1.2	2.7	7.2	402	0.2	0.9	3.3	837
Night	12-h	1.6	4.6	13.4	491	0.1	1.0	6.9	647
	24-h	1.6	2.9	9.0	482	0.2	0.9	4.1	655

Among blocks, the median forebay residence times of subyearling Chinook salmon ranged from 0.3 to 8.4 h during the 12-h treatment and from 0.5 to 1.8 h during the 24-h treatment (Figure 20). Within blocks, forebay residence times during the 12-h treatment were consistently longer in the day than at night early in the summer season (blocks 5 through 8), but later in the season (blocks 9 through 11) they were similar.

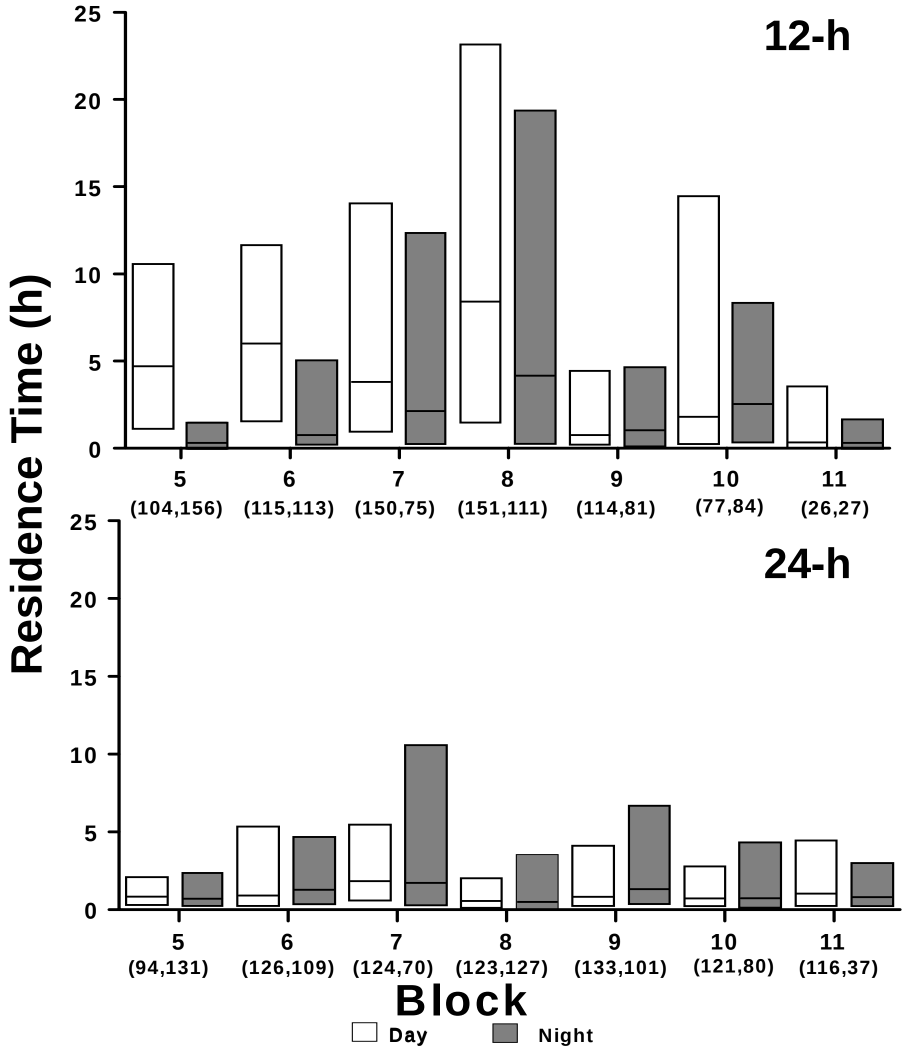

Figure 20. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged subyearling Chinook salmon forebay residence times by diel time of arrival during 12- and 24-h spill treatments at John Day Dam, 25 June through 23 July 2003. Day and night refer to two operational spill periods 0700-1959 h and 2000-0659 h. Sample sizes are in parentheses.

These observed differences were significant for 3 of the 4 early season blocks (Wilcoxon Rank Sum tests, $P < 0.05$, df = 1) and there were no significant differences later in the season. During the 24-h treatment, day and night residence times were similar within all blocks and no significant diel differences were found.

Differences in residence time between treatments during the 0 and 30% day spill were similar to the differences observed between 0% day spill and 60% night spill (Figure 20). Residence times were significantly longer during 0% than 30% spill during the day in blocks 5 through 8 (Wilcoxon Rank Sum tests, $P < 0.05$, df = 1), but were similar for blocks 9 through 11. At night, residence times were generally similar between the 30 and 60% spill levels and differed significantly only during block 5 when residence times during the 60% spill were shorter and during blocks 8 and 10 when residence times during 30% spill were shorter (Wilcoxon Rank Sum tests, $P \geq 0.05$, df = 1).

Differences in the variation in residence time within diel periods and treatments in Figure 18 can be attributed to a fish's time of arrival and the spill conditions encountered prior to passage. During the 12-h treatment, subyearling Chinook salmon arriving at JDA shortly after the switch from night to day spill conditions (0700 to 1100 hours) had the longest median forebay residence times, whereas fish arriving shortly after the switch from day to night spill conditions (2000-0259 hours) had the shortest median residence times (Table 11). Median residence times again increased for those fish that arrived just

Table 11. Median forebay residence times (h) of radio-tagged sub-yearling Chinook salmon by time of arrival (hours) and spill treatment at John Day Dam, summer 2003. Day and night refer to 12-h dam operating periods. 12-h = 0% day spill and 60% night spill. 24-h = 30% day and night spill. Sample sizes are shown in parentheses.

Time of arrival	Spill period	Spill treatment 12-h	Spill treatment 24-h
0700-1059	Day	4.5(314)	0.8(385)
1100-1459	Day	4.2(190)	1.1(235)
1500-1959	Day	2.9(233)	1.2(217)
2000-2259	Night	0.4(93)	0.8(115)
2300-0259	Night	0.2(224)	0.3(212)
0300-0659	Night	3.5(330)	1.4(328)

prior to the switch to no-spill (0300-0659 hours). During the 24-h treatment, fish arriving during day or night 30% spill passed relatively quickly regardless of when they arrived. These differences in median forebay residence times relative to spill and no-spill conditions were similar across blocks (Figure 20).

Despite longer forebay delays due to no spill, most fish passed during the same dam operating conditions present at their arrival. Sixty-nine percent of the fish arriving during 0% spill and 73% of the fish arriving during 60% spill passed during these spill conditions. During 30% day and night spill, 84 and 68% of the fish passed in the same diel period that they arrived. During the 12-h treatment, about 50% of the fish passed during both day and night; whereas during the 24-h treatment 61% of the fish passed during the day and 39% passed at night (Figure 21).

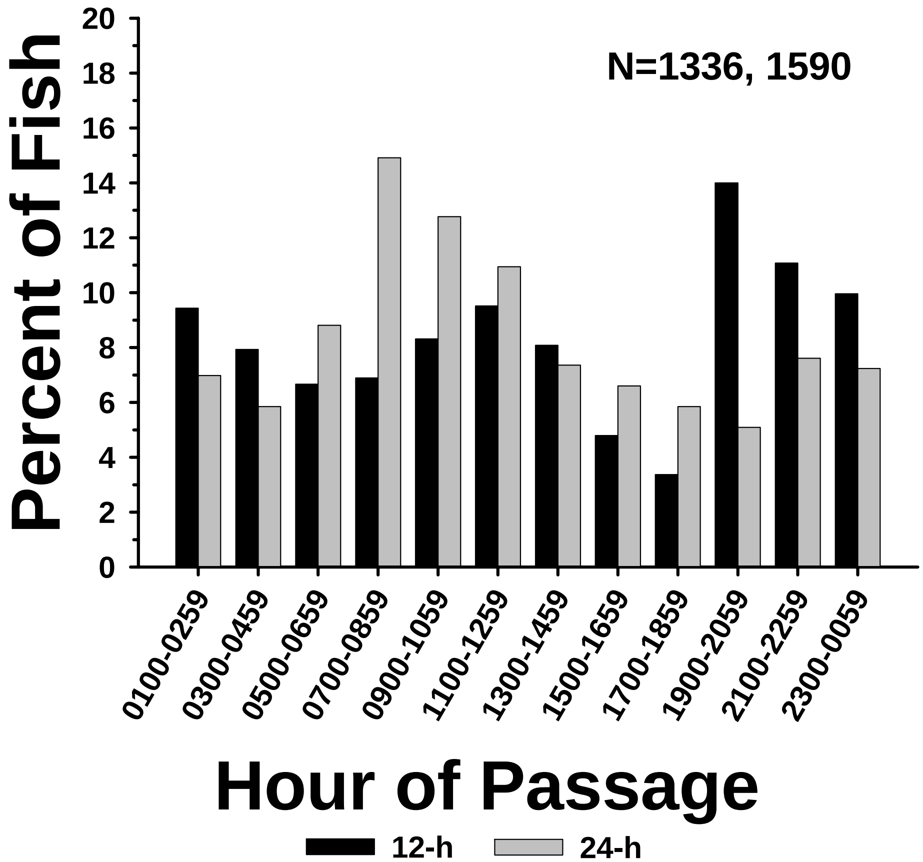

Figure 21. Hour of passage (2-h intervals) of radio-tagged subyearling Chinook salmon, John Day Dam, 25 June through 23 July 2003. All fish were released 23 km upriver of the dam near Rock Creek, Washington. 12-h = 0% day spill and 60% night spill. 24-h = 30% day and night spill. N = sample size.

Diel Detection Probabilities and General Route of Passage

Detection probabilities were high for all passage routes and had little effect on observed frequencies of radio-tagged subyearling Chinook salmon estimated to pass JDA via the three major passage routes. Detection probabilities at the spillway and JBS were greater than 0.99 regardless of diel period or treatment and at the powerhouse ranged from 0.97 to 0.99 (Table 12).

Table 12. Subyearling Chinook salmon diel capture histories and detection probabilities at telemetry arrays at the John Day Dam powerhouse, spillway, and juvenile fish bypass system (JBS), summer 2003. Capture history "10" = number of fish detected only on array 1, "01" = number of fish detected only on telemetry array 2, and "11" = number of fish detected on both array 1 and 2. P1 = probability of detection on array 1. P2 = probability of detection on array 2. P12 = probability of detection for array 1 and 2 combined.

Capture History	Day						Night					
	Powerhouse		Spillway		JBS		Powerhouse		Spillway		JBS	
	12-h	24-h	12-h	24-h	12-h	24-h	12-h	24-h	12-h	24-h	12-h	24-h
10	80	60	0	28	0	1	20	37	36	11	0	2
01	11	5	0	11	11	6	14	18	30	14	1	10
11	196	120	0	667	254	104	81	183	607	313	51	98
Total	287	185	0	706	265	111	115	238	673	338	52	110
Detection Probabilities												
P1	0.95	0.96	-	0.98	1.00	0.95	0.85	0.91	0.94	0.96	1.00	0.91
P2	0.71	0.67	-	0.96	0.96	0.99	0.80	0.83	0.95	0.97	0.98	0.98
P12	0.98	0.99	-	> 0.99	1.00	> 0.99	0.97	0.98	> 0.99	> 0.99	1.00	> 0.99

Predominant areas of passage varied because of changes in dam operations associated with the 12- and 24-h treatments, and day and night effects on subyearling Chinook salmon passage behavior. About equal numbers of fish passed through the JBS and powerhouse during 0% day spill, while fish passed predominantly through the spillway during periods of spill (Figure 22).

Most fish passing the dam via the powerhouse did so at the southern most turbines, while most spillway passage occurred at the north end of the spillway. Of the fish passing via the turbines, about 84% during day and 93% at night passed through turbines 1 through 8 (Figure 23). At the spillway, individual spill bay passage generally decreased from north to south (Figure 24). Sixty-eight percent of the fish passing through the spillway during the 12-h treatment passed via spill bays 1 through 10. During the 24-h spill treatment, 91% of the fish passed through spill bays 1 through 10. Both powerhouse and spillway passage patterns reflect the proportion of time that individual turbine units and spill bays were operating during the 12- and 24-h spill treatments (Appendices F and G).

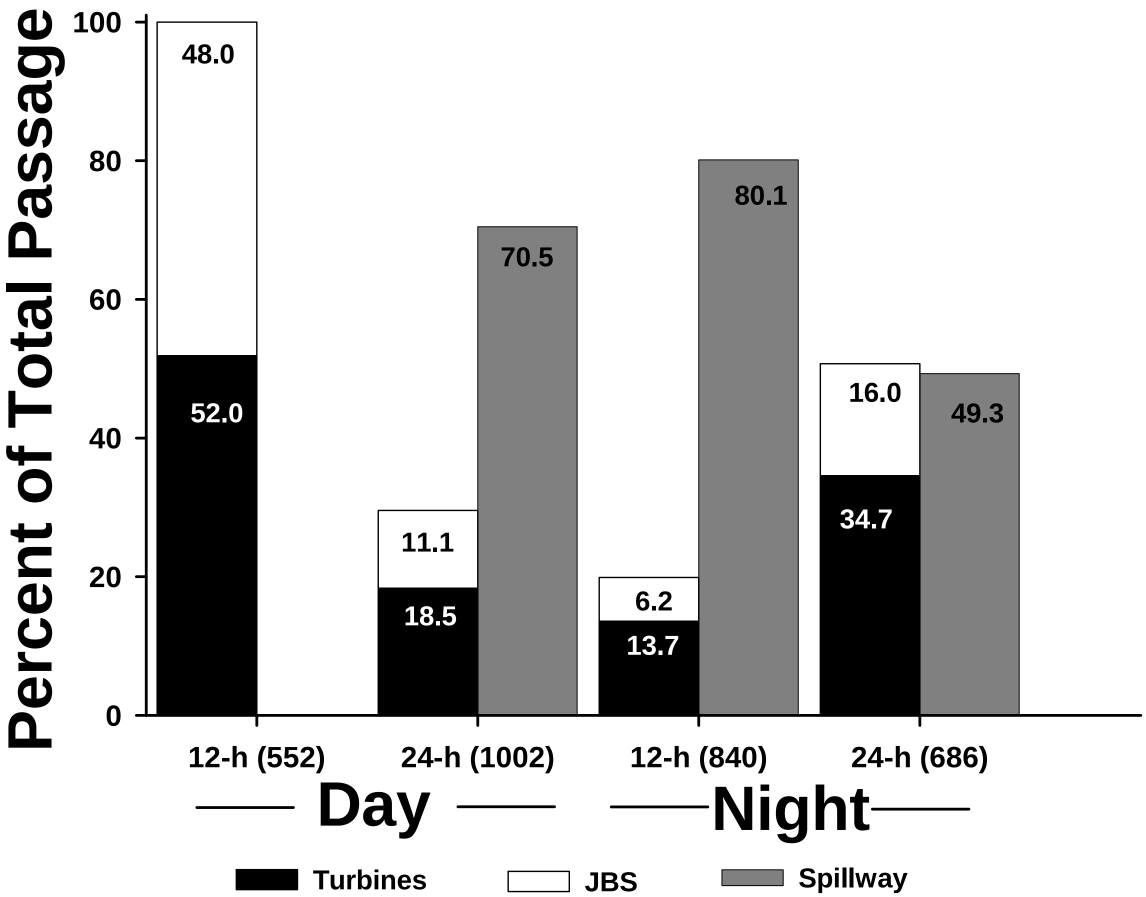

Figure 22. Radio-tagged subyearling Chinook salmon passage via the turbines, juvenile fish bypass system (JBS), and spillway at John Day Dam, 25 June through 23 July 2003. Day and night refer to 12-h operational spill periods. 12-h = 0% day spill and 60% night spill. 24-h = 30% day spill and 30% night spill. Sample sizes are in parentheses. Percent passage is on bars.

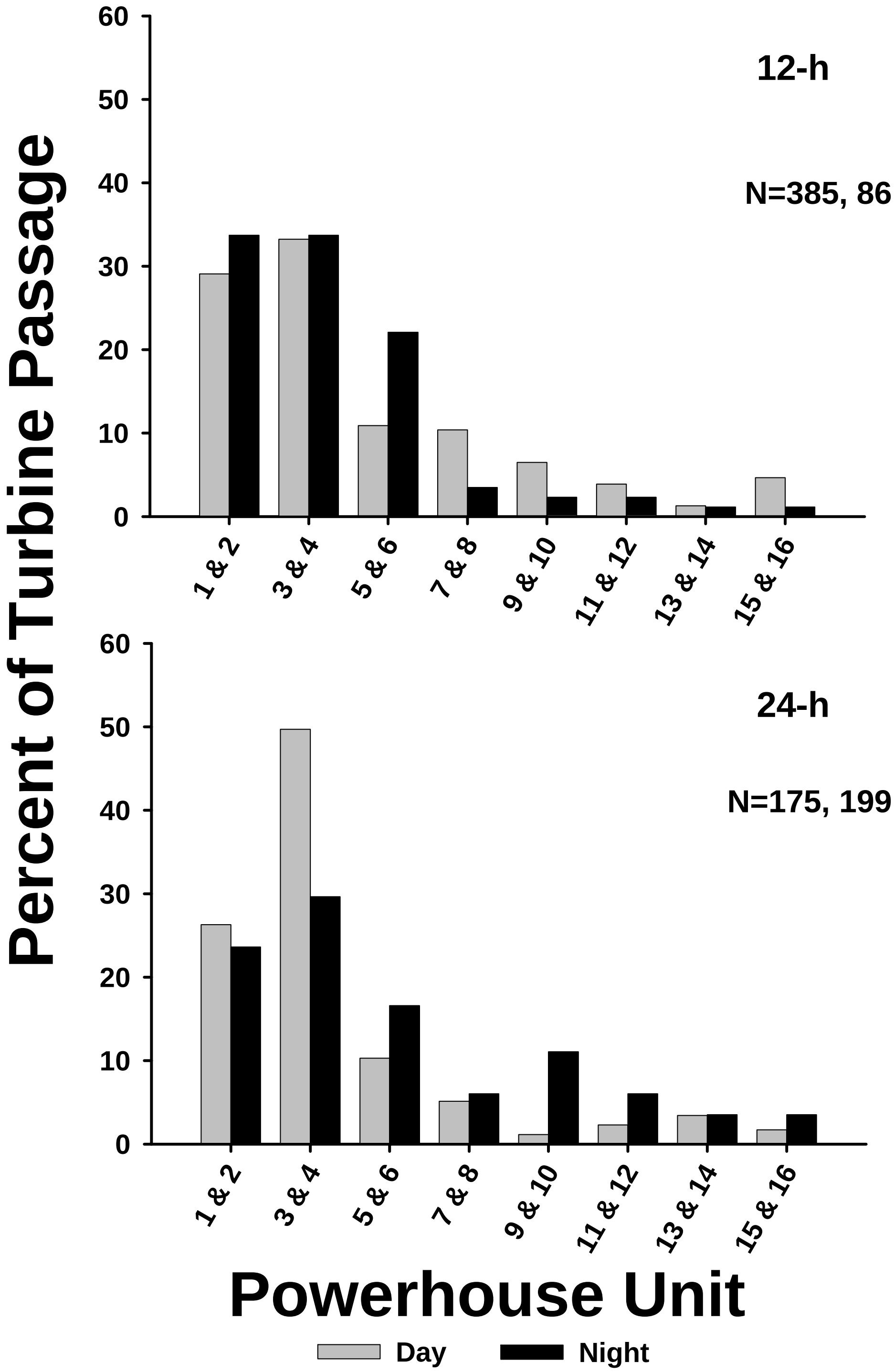

Figure 23. Percentage of radio-tagged subyearling Chinook salmon passage through powerhouse units 1 through 16 at John Day Dam, 25 June through 23 July 2003. Day and night refer to the two 12-h operational spill periods. 12-h = 0% day spill and 60% night spill. 24-h = 30% day spill and 30% night spill. N = day, night. Percents based on underwater antenna detections only.

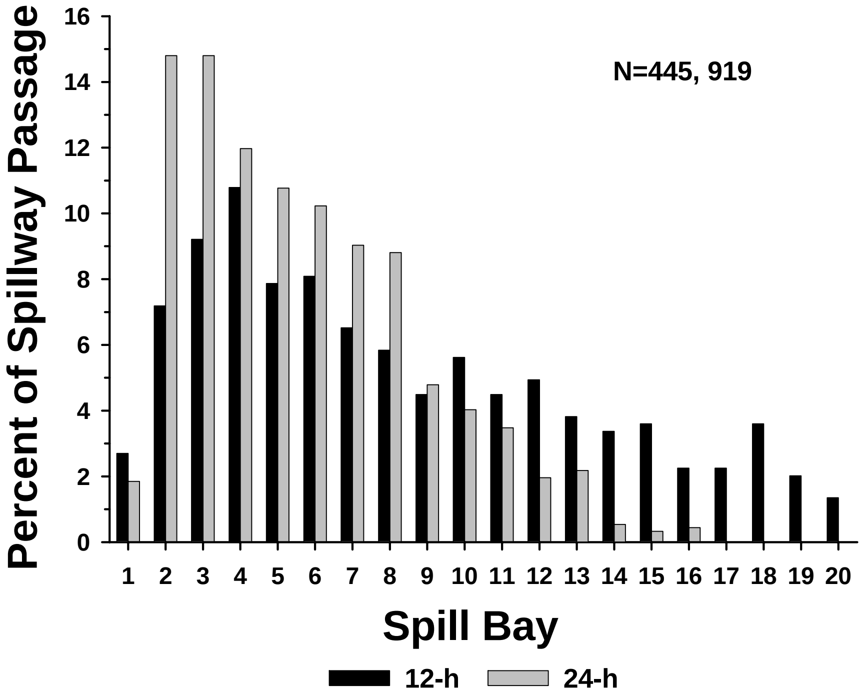

Figure 24. Percentage of radio-tagged subyearling Chinook salmon passage through tainter gates 1 through 20 at John Day Dam, 25 June through 23 July 2003. 12-h = 0% day spill and 60% night spill. 24-h = 30% day spill and 30% night spill. N = 12-h, 24-h. Percents are based on underwater antenna detections only.

Fish-, Spill-, and Juvenile Fish Bypass-Passage Efficiencies

No significant difference in overall subyearling Chinook salmon FPE was detected between the 12- and 24-h spill treatment (diel periods pooled; Chi-square test, $P = 0.07$, df = 1), but both SPE and JBYPE were significantly affected (Figure 25 and Table 13). The SPE was significantly less during the 12-h spill treatment than during the 24-h spill treatment (Chi-square test, $P = 0.02$, df = 1); whereas significantly more fish passed via the JBS during the 12-h treatment than the 24-h treatment (Chi-square test, $P = 0.01$, df = 1).

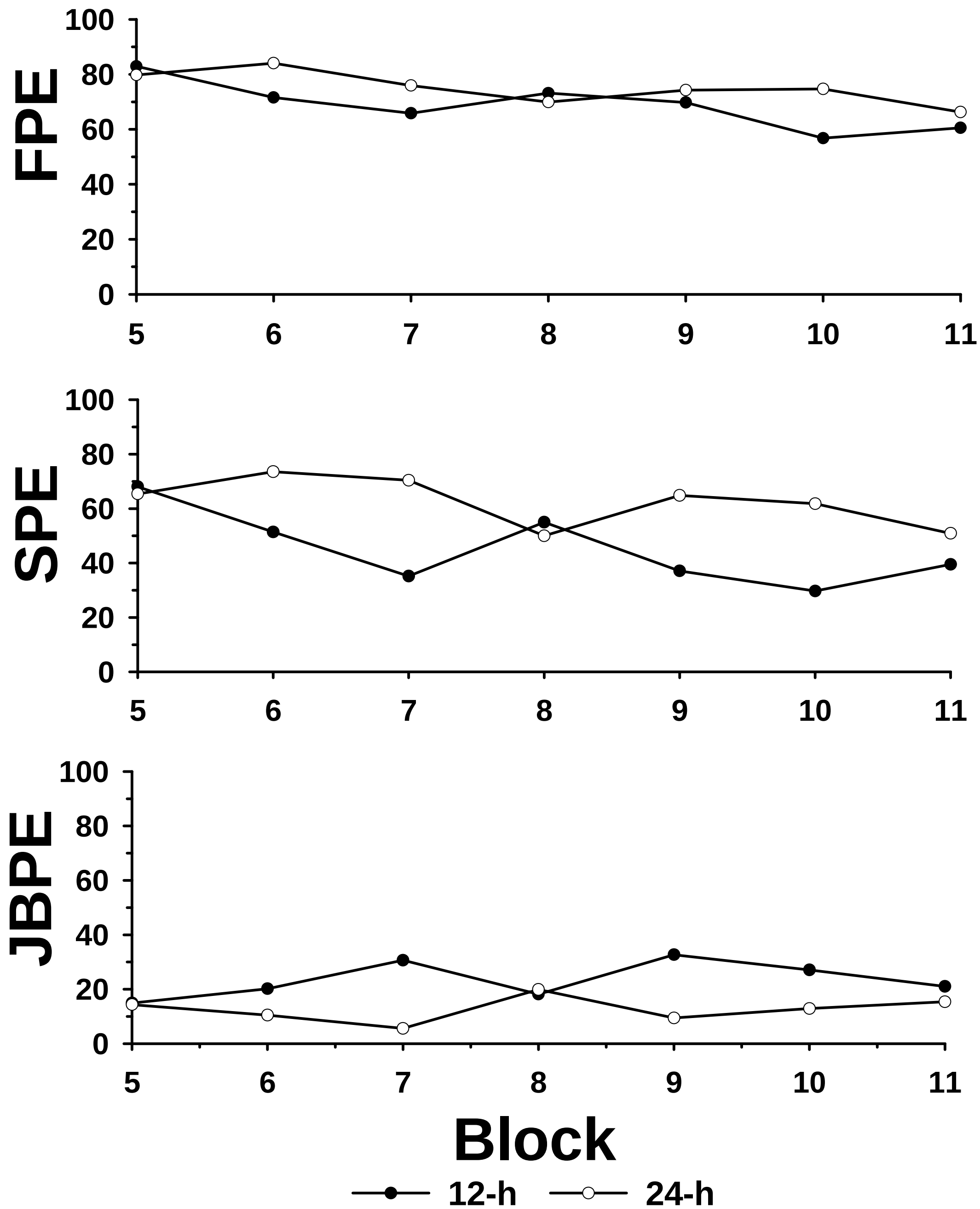

Figure 25. Overall radio-tagged subyearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass passage efficiency (JBYPE) by block at John Day Dam, 25 June through 23 July 2003. 12-h = 0% day spill and 60% night spill. 24-h = 30% day spill and 30% night spill. Sample sizes are given in Table 19.

Table 13. Pooled and diel passage estimates (Est) of subyearling Chinook salmon during 12 and 24-h spill treatments at John Day Dam, 25 June through 23 July 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at $\alpha = 0.05$ level.

		12-h			24-h		
Diel period	Passage efficiency	Est	95% LCRI	N	Est	95% LCRI	N
Pooled	FPE	70.7	64.7-76.4	1401	74.8	69.5-79.7	1691
	SPE *	48.1	38.7-57.6	1401	61.7	53.1-69.9	1691
	JBYPE *	22.6	17.8-28.0	1401	13.1	9.6-17.1	1691
Day	FPE *	47.5	38.2-57.0	557	81.5	75.6-86.5	1003
	SPE	-	-	-	70.4	59.9-79.6	1003
	JBYPE *	47.6	40.4-54.8	557	11.1	8.0-14.8	1003
Night	FPE *	86.0	82.3-89.3	844	65.1	59.7-70.3	688
	SPE *	79.9	75.2-84.0	844	49.1	43.1-55.2	688
	JBYPE *	6.2	4.2-8.6	844	16.0	12.5-20.0	688

Diel estimates of FPE, SPE, and JBYPE differed significantly between the 24- and 12-h spill treatments (Table 13). Day FPE was significantly less during the 12-h treatment than the 24-h treatment; whereas at night, FPE was less during the 24-h treatment (Figure 24 ; Chi-square tests, both P's < 0.0001, df = 1, Appendices N thru P). At night, SPE was significantly greater during 60% spill than 30% spill (Chi-square test, $P < 0.0001$, df = 1). Day JBYPE was significantly greater during the 12-h treatment than the 24-h treatment (Chi-square test, $P < 0.0001$, df = 1), but at night, JBYPE was significantly greater during the 24-h treatment (Chi-square test, $P < 0.0005$, df = 1).

Although SPE was significantly greater during 60% spill than 30% spill, 30% spill was more effective at passing fish through the spillway per volume of water, and day spill was more effective than night spill. The spill effectiveness for these spill conditions was as follows: day 30 % spill, 2.3; night 30% spill, 1.6; night 60% spill, 1.3.

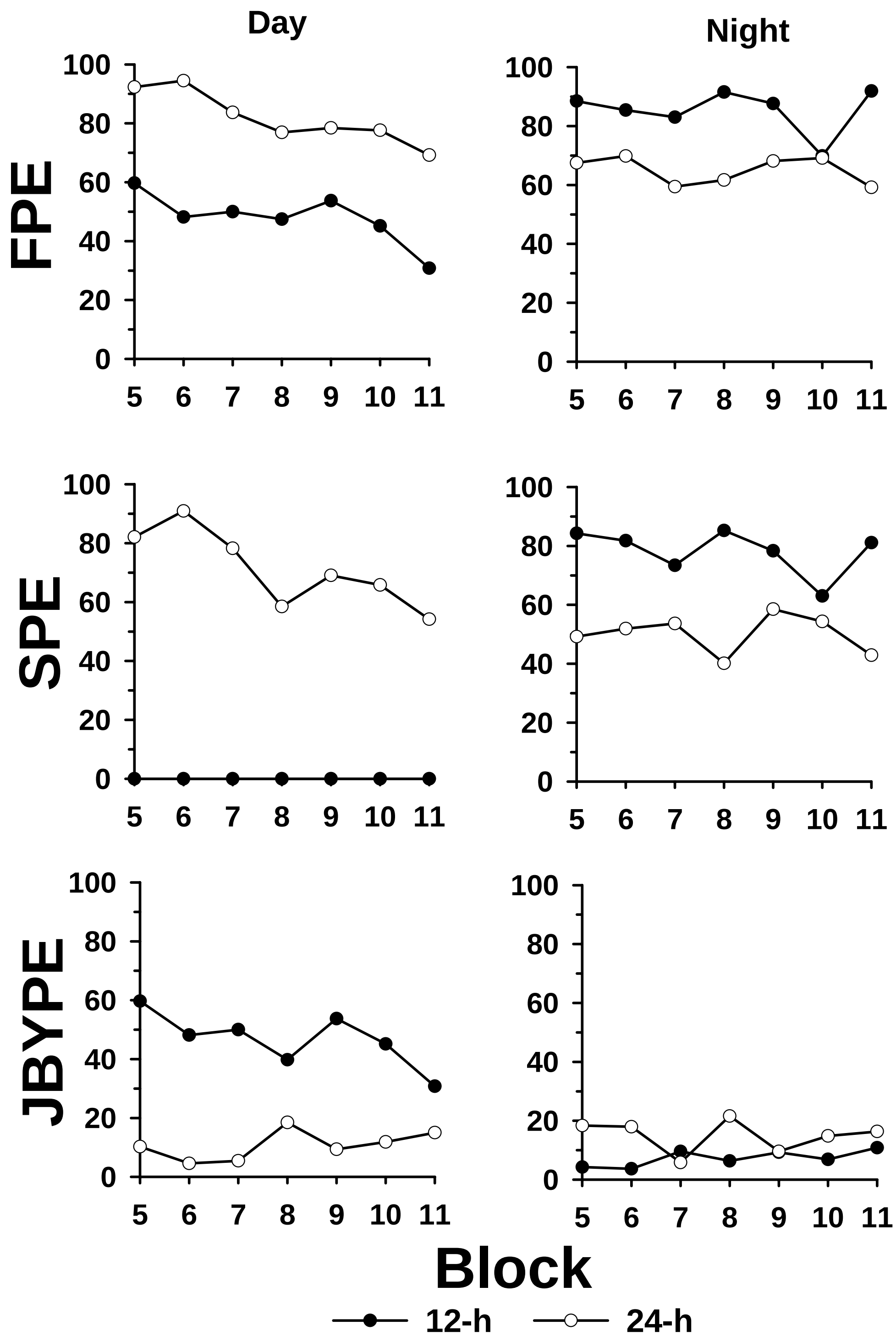

Figure 24. Diel estimates of radio-tagged subyearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass passage efficiency by block at John Day Dam, 25 June through 23 July 2003. 12-h = 0% day spill and 60% night spill. 24-h = 30% day spill and 30% night spill. Sample sizes are given in Tables 19 through 21.

Discussion

This study was the fourth year 12- and 24-h spill treatments were tested at John Day Dam since 1999. The results are similar among years, though the treatments have varied due to physical operating constraints (e.g., a maximum of 45% spill in 1999 due to total dissolved gas generation downstream) and adaptive management between years based on the results at hand. In general, the treatment spill scenarios tested since 1999 have not resulted in significant improvements in FPE from spill mandated in the Biological Opinion (0% day spill, 60% night spill; Table 22). However, FPE during the day and FPE during the night were changed significantly as were the proportions of fish passing via the spillway and juvenile bypass system.

Results of this study indicate that overall non-turbine passage (FPE) of yearling and subyearling Chinook salmon were not significantly different between the spill treatments in 2003 at the $\alpha = 0.05$ level. This is similar to results of studies of yearling and subyearling Chinook salmon in 1999, 2000 and 2002, with one exception (Table 14). The exception was the FPE of subyearling Chinook salmon in 2000, which was significantly greater during a 24-h spill treatment than a 12-h treatment; however, the 24-h treatment in 2000 included more spill than the treatment tested in 2003 (30% day spill and 53% night spill in 2000 vs. 24-h 30% spill in 2003; Beeman et al. 2003). Though no significant difference was present at the $\alpha = 0.05$ level, the FPE of subyearling chinook salmon during the 24-h treatment in 2003 was significantly greater than the 12-h treatment at the $\alpha = 0.10$ level ($P = 0.07$).

Table 14. Estimated percent fish passage efficiency (FPE) during studies of spill at John Day Dam from 1999 to 2003. The 95% likelihood ratio confidence intervals are in parentheses following the point estimates. Data from 1999, 2000 and 2002 are from Hansel et al. 2000, Beeman et al. 2003, and Beeman et al. In preparation. The treatment difference of subyearling Chinook salmon in 2000 was the only significant difference in FPE at the $\alpha = 0.05$ level.

Spill Treatment (Day% / Night%)	Year	Yearling Chinook	Juvenile Steelhead	Subyearling Chinook
12-h (0/45)	1999	82.5 (75.5, 88.1)	94.2 (88.9,97.5)	na
24-h (30/45)	1999	87.5 (81.4, 92.2)	90.4 (84.6, 94.5)	na
12-h (0/53)	2000	84.6 (74.8, 91.8)	93.0 (89.0, 96.0)	78.7 (71.5,84.9)
24-h (30/53)	2000	91.3 (83.7, 96.2)	91.3 (87.2, 94.5)	91.1 (86.0, 94.9)
12-h (0/54)	2002	84.1 (79.8, 87.9)	85.2 (77.8, 90.9)	71.8 (67.8, 75.6)
24-h (30/30	2002	79.9 (75.3, 84.1)	89.9 (82.2, 95.2)	70.4 (66.6, 74.0)
12-h (0/45)	2003	83.6 (80.6, 86.4)	na	na
12-h (0/60)	2003	85.7 (83.0, 88.2)	na	na
12-h (0/60)	2003	na	na	70.7 (64.7, 76.4)
24-h (30/30	2003	na	na	74.8 (69.5, 79.7)

Results from 2003 and other recent studies of 12- and 24-h spill at John Day Dam based on radio telemetry have shown that the treatments have resulted in significant, albeit compensatory, changes in passage via the spillway and juvenile bypass system (Hansel et al. 2000, Beeman et al. 2003, Beeman et al. In preparation). For example, during the tests of the two 12-h treatments in the spring of 2003 the significantly lower SPE of yearling chinook salmon during 45% night spill compared to 60% night spill was compensated for by significant increases in passage via the JBS (16% vs. 10%) and an increase in spill effectiveness during the 45% treatment (1.6 vs. 1.3), resulting in no significant difference in FPE. Similar trends were evident during the summer of 2003, when passage of subyearling Chinook salmon during 12-h and 24-h treatments was evaluated.

The applicability of our results to untagged in-river migrants is dependent on their hour of arrival at JDA. Radio-tagged yearling and subyearling Chinook salmon arrival at JDA was about equally distributed throughout the day and night, but the arrival of untagged in-river fish is unknown. During the spring of 2003, run-of-river scenarios in which migrants arrived at JDA predominantly during the day or alternatively at night would have little effect on the relevancy of our results since spill was only present at night in each treatment. However, this does not imply that either 12-h treatment would necessarily be the best dam operation scenario for a population of spring migrants that arrived primarily during the day since 0% spill resulted in longer forebay residence time of these fish. The biological impact of longer forebay residence time is dependent on the potential for exposure to predators or other deleterious environmental conditions in the forebay and the cumulative effects of such exposure at many dams that may decrease fish survival. During summer, dam operations (i.e. spill) had little affect on forebay residence times, and subyearling Chinook salmon migrate during the day and night (Venditti et al. 2000), so it seems reasonable to expect the arrival of these fish is spread throughout the day and night.

The time of dam passage of yearling Chinook salmon during the 12-h treatments tested in 2003 was primarily during the night, but subyearling Chinook salmon passed near the time of their arrival. These results are similar to those of previous passage studies based on fixed hydroacoustics and radio telemetry. Studies of fish passage during 12- and 24-h spill treatments based on fixed hydroacoustics indicate that dam passage is primarily during the evening during the spring and summer, though the difference between day and night passage is greater during the spring (Moursund et al. 2001, 2003). Moursund et al. (2003) also noted a peak in spill passage with the onset of night spill, prior to the main period of night passage, indicating pulses of spill may be beneficial for passing juvenile salmonids at John Day Dam. Results from studies based on radio telemetry also indicate that most fish pass primarily during the night during the spring and that there are species-specific differences in passage timing. Studies in 1999, 2000 and 2002 indicated that most juvenile steelhead arriving during the day delayed passage until the night with or without 30% day spill, whereas about 40% of the yearling Chinook salmon arriving during the day passed via the spillway when 30% spill was present (Beeman et al. 2003). These studies also indicated subyearling Chinook salmon (summer migrants) passed shortly after arrival and the spill conditions at the time of their arrival had little effect on their time of passage.

In summary, this study indicated there were no significant differences in FPE of yearling or subyearling Chinook salmon between the spill treatments tested in 2003. The treatments during the passage of yearling Chinook salmon were composed of 0% day spill and 45% night spill vs. 0% day spill and 60% night spill. Those during passage of subyearling Chinook salmon were 0% day spill and 60% night spill vs. 24-h 30% spill. Compensatory changes in passage via the spillway and juvenile bypass system have resulted in no significant changes in FPE during most spill treatments tested since 1999. However, other spill operations, such as pulses of spill, have not been tested at this facility.

Acknowledgements

We thank Mike Langeslay, Rock Peters, Miro Zyndol, and other USACE personnel for their efforts in managing our contract and assisting in planning and executing this research. This work would not have been accomplished without the efforts and technical assistance of Laura Dingmon, Brad Liedtke, Eric Winters, Linda Kelley, Tyler Mitchell, Rod Polintan, Cory Wright, and Tammy Wilkerson ; Theresa Liedtke and the John Day egress crew, who tagged and released some of the fish we used for this study, and; Tim Counihan and his survival team who helped with data processing. We thank Rick Martinson and Greg Kovalchuk of the Pacific States Marine Fisheries Commission and the staff at John Day Dam for collecting and holding fish for this study.

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Appendices

Appendix A. Release date, release time (hours), sample size (N), percent detected (% Det.), mean, standard deviation (SD), and range of fork lengths (mm) and weights (g) of yearling Chinook salmon released into Rock Creek above John Day Dam during spring 2003.

Release date	Release time	N	% Det.	Fork Length (mm)			Weight (g)		
				Mean	SD	Range	Mean	SD	Range
27 April	2100	31	96.8	160	10.8	138-182	38.4	7.7	27.1-58.5
28 April	0900	33	90.9	160	11.6	134-197	39.6	9.6	22.7-71.6
29 April	2100	26	96.2	167	8.3	152-184	43.8	7.3	32.3-56.4
30 April	0900	34	94.1	162	12.1	137-191	42.7	11.4	25.3-82.5
01 May	2100	33	97.0	163	12.7	139-194	42.6	9.3	28.1-66.3
02 May	0900	27	100.0	160	14.0	130-190	40.2	10.9	21.4-68.5
03 May	2100	32	93.8	159	13.6	140-190	41.4	10.3	26.2-65.7
04 May	0900	34	91.2	158	11.9	136-181	39.5	8.1	26.4-57.3
05 May	2100	35	100.0	152	17.0	125-200	36.3	13.1	18.8-81.4
06 May	0900	30	100.0	159	15.4	138-200	40.4	13.4	25.0-85.6
07 May	2100	35	94.3	153	16.5	127-195	36.6	12.9	22.5-73.6
08 May	0900	37	91.9	159	17.7	130-190	34.2	15.8	4.3-67.9
09 May	2100	33	97.0	153	16.1	130-189	37.0	11.3	21.8-65.7
10 May	0900	34	91.2	157	15.6	134-190	38.9	12.4	23.5-72.1
11 May	2100	37	97.3	153	18.4	122-206	36.1	13.8	18.1-80.1
12 May	0900	35	91.4	151	16.2	124-185	33.6	11.2	18.2-61.6
13 May	2100	38	97.4	155	20.5	132-197	37.2	15.6	21.7-72.8
14 May	0900	37	89.2	158	18.7	126-191	37.8	13.8	18.3-65.2
15 May	2100	34	94.1	152	16.2	131-200	35.2	13.0	21.6-81.1
16 May	0900	33	87.9	157	16.9	126-190	37.4	12.1	20.0-64.3
17 May	2100	35	82.9	153	21.2	122-210	34.4	15.7	18.3-88.3
18 May	0900	35	94.3	156	19.9	131-205	36.9	15.3	21.3-79.4
19 May	2100	37	94.6	157	17.8	132-203	38.5	14.6	18.1-82.2
20 May	0900	38	92.1	155	18.8	132-210	37.5	17.2	19.3-99.9
21 May	2100	37	94.6	153	15.1	132-200	32.7	10.6	20.8-72.3
22 May	0900	37	100.0	152	16.5	132-195	33.9	12.4	20.2-70.9
23 May	2100	37	97.3	152	15.0	131-193	34.3	11.9	20.6-72.2
24 May	0900	38	94.7	148	15.4	130-191	30.8	10.0	19.4-64.5
25 May	2100	36	88.9	160	22.1	130-220	40.7	21.0	19.9-118
26 May	0900	38	97.4	152	12.8	134-185	32.4	8.8	21.5-53.6
27 May	2100	38	100.0	150	17.1	129-205	32.5	14.0	21.3-84.8
28 May	0900	37	97.3	156	20.9	132-220	37.5	20.2	19.5-113.7
29 May	2100	35	94.3	152	17.7	131-213	34.6	16.2	22.1-95.5
30 May	0900	36	97.2	150	15.7	128-205	31.8	12.4	20.8-82.4
31 May	2100	35	85.7	151	20.5	128-217	35.2	18.2	19.5-100.6
01 June	0900	34	100.0	151	16.8	134-214	33.4	15.6	19.5-94.6
02 June	2100	36	97.2	150	12.9	130-199	32.4	9.2	21.2-72.8
03 June	0900	34	97.1	153	14.6	133-195	34.6	10.6	22.1-69.9
04 June	2100	34	97.1	151	11.5	128-185	32.0	8.0	19.6-56.0
05 June	0900	34	97.1	154	14.6	138-209	34.4	10.8	23.9-83.8
Overall:		1389	94.7	155	16.6	122-220	36.3	13.4	4.3-118.0

Appendix B. Yearling Chinook salmon spillway (SP), powerhouse (PH), and juvenile fish bypass (JBS) passage counts by block, treatment, date, and diel at John Day Dam, spring 2003.

Species	Block	Treatment	Date	Diel	SP	PH	JBS
CH1	02	00/45	4/30/2003	Day	0	1	3
CH1	02	00/45	4/30/2003	Night	9	0	2
CH1	02	00/45	5/1/2003	Day	0	2	7
CH1	02	00/45	5/1/2003	Night	21	4	3
CH1	02	00/45	5/2/2003	Night	3	1	1
CH1	02	00/60	4/28/2003	Day	0	0	2
CH1	02	00/60	4/28/2003	Night	6	3	0
CH1	02	00/60	4/29/2003	Day	0	2	7
CH1	02	00/60	4/29/2003	Night	19	0	4
CH1	02	00/60	4/30/2003	Night	4	0	2
CH1	03	00/45	5/4/2003	Day	0	1	1
CH1	03	00/45	5/4/2003	Night	4	1	0
CH1	03	00/45	5/5/2003	Day	0	2	9
CH1	03	00/45	5/5/2003	Night	14	3	4
CH1	03	00/45	5/6/2003	Night	4	0	1
CH1	03	00/60	5/2/2003	Day	0	2	0
CH1	03	00/60	5/2/2003	Night	12	0	1
CH1	03	00/60	5/3/2003	Day	0	4	6
CH1	03	00/60	5/3/2003	Night	18	2	2
CH1	03	00/60	5/4/2003	Night	5	0	2
CH1	04	00/45	5/6/2003	Day	0	2	5
CH1	04	00/45	5/6/2003	Night	10	0	3
CH1	04	00/45	5/7/2003	Day	0	6	16
CH1	04	00/45	5/7/2003	Night	23	0	1
CH1	04	00/45	5/8/2003	Night	3	0	1
CH1	04	00/60	5/8/2003	Day	0	1	4
CH1	04	00/60	5/8/2003	Night	9	3	0
CH1	04	00/60	5/9/2003	Day	0	3	15
CH1	04	00/60	5/9/2003	Night	26	3	3
CH1	04	00/60	5/10/2003	Night	3	1	1
CH1	05	00/45	5/10/2003	Day	0	1	5
CH1	05	00/45	5/10/2003	Night	6	2	0
CH1	05	00/45	5/11/2003	Day	0	5	7
CH1	05	00/45	5/11/2003	Night	13	1	2
CH1	05	00/45	5/12/2003	Night	5	0	0
CH1	05	00/60	5/12/2003	Day	0	4	5
CH1	05	00/60	5/12/2003	Night	10	0	1
CH1	05	00/60	5/13/2003	Day	0	3	4
CH1	05	00/60	5/13/2003	Night	43	2	2
CH1	05	00/60	5/14/2003	Night	5	0	1
CH1	06	00/45	5/16/2003	Day	0	1	3

Appendix B. Continued.

Species	Block	Treatment	Date	Diel	SP	PH	JBS
CH1	06	00/45	5/16/2003	Night	13	1	1
CH1	06	00/45	5/17/2003	Day	0	3	6
CH1	06	00/45	5/17/2003	Night	20	5	4
CH1	06	00/45	5/18/2003	Night	1	0	0
CH1	06	00/60	5/14/2003	Day	0	3	16
CH1	06	00/60	5/14/2003	Night	27	1	1
CH1	06	00/60	5/15/2003	Day	0	1	4
CH1	06	00/60	5/15/2003	Night	19	3	2
CH1	06	00/60	5/16/2003	Night	2	1	1
CH1	07	00/45	5/20/2003	Day	0	2	6
CH1	07	00/45	5/20/2003	Night	6	1	0
CH1	07	00/45	5/21/2003	Day	0	0	15
CH1	07	00/45	5/21/2003	Night	9	11	5
CH1	07	00/45	5/22/2003	Night	1	4	2
CH1	07	00/60	5/18/2003	Day	0	3	0
CH1	07	00/60	5/18/2003	Night	13	1	1
CH1	07	00/60	5/19/2003	Day	0	3	6
CH1	07	00/60	5/19/2003	Night	21	4	2
CH1	07	00/60	5/20/2003	Night	5	1	0
CH1	08	00/45	5/24/2003	Day	0	5	13
CH1	08	00/45	5/24/2003	Night	12	1	0
CH1	08	00/45	5/25/2003	Day	0	0	3
CH1	08	00/45	5/25/2003	Night	27	3	1
CH1	08	00/45	5/26/2003	Night	1	0	1
CH1	08	00/60	5/22/2003	Day	0	4	7
CH1	08	00/60	5/22/2003	Night	8	3	0
CH1	08	00/60	5/23/2003	Day	0	2	8
CH1	08	00/60	5/23/2003	Night	42	3	4
CH1	08	00/60	5/24/2003	Night	1	1	0
CH1	09	00/45	5/26/2003	Day	0	1	5
CH1	09	00/45	5/26/2003	Night	9	4	0
CH1	09	00/45	5/27/2003	Day	0	2	10
CH1	09	00/45	5/27/2003	Night	20	4	12
CH1	09	00/45	5/28/2003	Night	0	1	1
CH1	09	00/60	5/28/2003	Day	0	5	26
CH1	09	00/60	5/28/2003	Night	18	1	2
CH1	09	00/60	5/29/2003	Day	0	2	5
CH1	09	00/60	5/29/2003	Night	9	3	4
CH1	10	00/45	5/30/2003	Day	3	3	16
CH1	10	00/45	5/30/2003	Night	15	4	7
CH1	10	00/45	5/31/2003	Day	0	1	2
CH1	10	00/45	5/31/2003	Night	6	2	4
CH1	10	00/60	6/1/2003	Day	1	3	25
CH1	10	00/60	6/1/2003	Night	13	2	0

Appendix B. Continued.

Species	Block	Treatment	Date	Diel	SP	PH	JBS
CH1	10	00/60	6/2/2003	Day	0	2	6
CH1	10	00/60	6/2/2003	Night	10	1	3
CH1	11	00/45	6/3/2003	Day	0	2	20
CH1	11	00/45	6/3/2003	Night	20	4	5
CH1	11	00/45	6/4/2003	Day	0	2	3
CH1	11	00/45	6/4/2003	Night	9	0	3
CH1	11	00/60	6/5/2003	Day	0	4	5
CH1	11	00/60	6/5/2003	Night	28	3	3
CH1	11	00/60	6/6/2003	Day	0	0	1
CH1	11	00/60	6/6/2003	Night	12	5	5

Appendix C. Percentage of time main turbine units 1 through 16 (MU1-MU16) and spill bays 1 through 20 (SB1-SB20) were in operation during day no spill by treatment (00/45 and 00/60) and block at John Day Dam, spring 2003. Darker shading indicates greater percentage.

	Treatment and Block																			
	00/45										00/60									
Unit	2	3	4	5	6	7	8	9	10	11	2	3	4	5	6	7	8	9	10	11
MU1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	96	100	100	100	100	100
MU3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU5	100	100	100	100	100	0	100	100	100	100	100	100	100	100	100	54	96	100	100	100
MU6	100	50	92	46	100	100	100	100	100	100	92	63	96	71	80	100	100	100	100	100
MU7	100	100	92	100	100	100	100	100	100	100	92	79	100	67	100	100	100	100	100	100
MU8	96	21	21	92	100	100	100	100	100	100	100	96	96	96	96	88	100	100	85	100
MU9	29	100	92	50	100	92	100	100	100	100	0	75	100	100	100	100	100	100	100	100
MU10	100	88	100	100	100	100	100	100	100	0	100	96	96	96	96	100	100	100	50	77
MU11	92	100	96	96	96	92	100	96	100	100	100	58	92	46	96	96	100	96	100	96
MU12	96	96	92	75	65	81	92	100	100	100	92	83	92	92	68	96	100	96	96	100
MU13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU14	100	96	100	96	100	100	96	100	100	100	100	96	96	96	92	88	96	96	96	100
MU15	96	0	96	46	100	0	100	100	100	100	100	100	88	0	80	27	92	100	100	96
MU16	92	100	100	96	31	100	0	0	100	100	92	0	96	100	80	88	38	92	100	100
SB1	17	0	13	13	12	31	15	15	4	50	0	33	17	8	12	23	15	19	15	23
SB2	8	21	13	13	15	8	8	8	100	46	0	21	17	17	12	8	8	8	38	12
SB3	8	17	13	13	8	8	8	8	100	46	0	17	17	21	12	8	8	8	38	12
SB4	4	17	13	13	12	8	8	8	100	42	0	17	17	17	12	12	8	8	38	8
SB5	4	17	13	13	8	8	8	8	100	42	0	17	17	17	12	18	4	8	12	8
SB6	8	17	13	13	15	8	12	8	100	46	0	17	17	17	12	15	12	12	12	12
SB7	8	17	13	13	15	12	12	8	100	46	0	17	17	21	12	15	12	12	12	12
SB8	8	17	13	13	15	8	8	8	100	31	0	17	17	21	16	15	8	8	8	8
SB9	8	17	13	13	15	8	12	8	100	38	0	17	17	17	12	15	8	12	12	12
SB10	8	42	13	33	42	23	27	38	100	81	0	38	42	25	12	54	35	27	50	27
SB11	8	17	25	13	15	8	12	8	65	38	0	13	17	17	12	15	12	12	12	12
SB12	4	17	13	13	15	8	12	8	65	8	0	13	17	17	12	15	12	12	12	8
SB13	13	25	13	29	35	31	31	8	100	77	0	42	38	25	28	31	46	35	54	23
SB14	13	17	21	21	15	15	19	23	69	42	0	21	29	21	16	27	19	19	42	27
SB15	8	17	13	13	15	8	12	12	15	12	0	17	17	17	12	15	8	15	12	12
SB16	8	17	13	13	15	8	12	8	15	8	0	17	17	17	12	15	12	12	12	8
SB17	8	17	13	13	15	8	12	8	15	12	0	17	17	17	12	15	12	12	12	8
SB18	8	17	13	13	15	8	12	8	31	19	0	17	17	17	12	15	12	12	19	12
SB19	8	13	13	8	15	8	12	8	8	12	0	17	17	17	12	15	12	12	12	12
SB20	8	13	8	4	15	8	12	8	8	12	0	17	17	17	12	15	8	12	12	12

Appendix D. Percentage of time main turbine units 1 through 16 (MU1-MU16) and spill bays 1 through 20 (SB1-SB20) were in operation during 45 and 60% night spill by block at John Day Dam, spring 2003. Darker shading indicates greater percentage.

	Treatment and Block																			
	45% spill										60% spill									
Unit	2	3	4	5	6	7	8	9	10	11	2	3	4	5	6	7	8	9	10	11
MU1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU2	100	100	100	100	100	100	100	100	100	100	100	100	100	96	100	100	100	100	100	100
MU3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	82	100	100
MU5	100	100	100	100	100	0	100	100	100	100	100	100	100	100	100	50	100	100	100	100
MU6	25	33	58	0	100	77	77	100	100	64	5	0	46	4	52	55	27	77	55	23
MU7	71	100	63	83	100	100	100	100	100	100	0	21	100	42	83	32	68	64	73	32
MU8	29	0	50	8	100	64	50	55	95	59	68	21	13	38	26	32	59	59	59	41
MU9	21	92	67	67	100	73	73	82	100	100	0	50	17	33	65	5	45	41	100	55
MU10	71	54	100	4	100	100	91	73	100	0	11	4	13	25	26	73	68	73	0	45
MU11	8	13	25	17	18	9	14	86	18	77	0	4	8	4	4	5	5	14	36	14
MU12	13	13	21	8	9	14	14	59	14	64	42	8	13	13	13	9	18	32	36	41
MU13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU14	17	13	21	21	45	18	18	82	18	100	11	13	13	17	17	14	9	32	41	36
MU15	100	8	38	0	100	0	100	77	100	100	0	21	25	4	57	0	41	41	50	14
MU16	29	88	100	46	0	100	0	0	100	50	11	8	13	17	57	77	5	68	82	86
SB1	38	0	0	0	23	23	55	59	91	64	79	54	0	42	70	41	64	73	91	68
SB2	92	100	92	92	91	91	95	95	100	91	89	92	96	96	91	91	95	95	95	95
SB3	92	100	92	92	91	91	95	95	100	91	89	92	96	96	91	91	95	95	100	95
SB4	92	100	92	92	91	95	95	95	100	91	89	92	96	96	91	91	95	95	95	95
SB5	92	100	92	92	95	91	95	100	100	91	89	92	96	96	91	91	68	95	95	95
SB6	92	100	92	92	91	91	100	100	100	91	89	92	96	96	91	91	95	100	95	95
SB7	92	100	92	92	91	95	95	100	100	91	89	92	96	96	91	91	95	100	95	95
SB8	92	100	92	92	91	91	95	95	100	91	89	92	96	96	96	91	95	95	95	95
SB9	92	100	92	92	91	91	95	100	100	91	89	92	96	96	91	91	100	100	95	95
SB10	92	100	96	92	95	91	100	100	100	91	89	96	96	96	96	91	95	100	100	100
SB11	92	100	92	92	91	91	95	100	100	91	89	92	96	96	91	91	95	100	95	68
SB12	92	100	92	92	91	91	95	100	100	91	89	92	96	96	96	91	95	100	95	95
SB13	92	100	92	92	91	95	100	100	100	91	89	96	96	96	100	91	100	100	95	100
SB14	92	100	92	92	100	95	95	100	95	91	95	92	100	100	91	91	95	100	95	95
SB15	92	100	92	92	95	91	95	100	95	91	89	92	96	100	96	91	95	100	95	95
SB16	92	100	92	92	91	91	95	100	95	91	89	92	96	96	96	91	95	100	91	95
SB17	92	96	92	92	95	91	100	100	95	91	89	92	100	96	96	91	95	100	91	95
SB18	88	96	92	92	91	91	95	100	95	91	89	92	96	96	96	91	95	95	95	95
SB19	58	75	67	92	95	64	95	100	95	91	89	92	100	96	96	91	95	95	91	95
SB20	58	46	63	92	91	50	95	100	95	91	89	92	96	96	91	91	95	77	91	95

Appendix E. Estimates of yearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass passage efficiency (JBYPE) during 00/60 and 00/45 spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 28 April through 07 June 2003. LRCI = likelihood ratio confidence interval. N = sample size.

Fish passage efficiency

	00/45			00/60			Observed
Block	FPE	N	Odds	FPE	N	Odds	odds ratio
2	86.0	57	6.125	89.8	49	8.800	1.437
3	84.1	44	5.286	85.2	54	5.750	1.088
4	88.6	70	7.750	84.7	72	5.545	0.715
5	80.9	47	4.222	88.8	80	7.889	1.869
6	82.8	58	4.800	88.9	81	8.000	1.667
7	71.0	62	2.444	80.0	60	4.000	1.637
8	86.6	67	6.444	84.3	83	5.384	0.836
9	82.6	69	4.750	85.3	75	5.818	1.225
10	84.1	63	5.300	87.9	66	7.250	1.368
11	88.2	68	7.500	81.8	66	4.500	0.600

Overall odds ratio adjusted for blocks 2-11 (95% LRCI) 1.165(0.858-1.582)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.33

Spill passage efficiency

	00/45			00/60			Observed
Block	SPE	N	Odds	SPE	N	Odds	odds ratio
2	57.9	57	1.375	59.2	49	1.450	1.055
3	50.0	44	1.000	64.8	54	1.842	1.842
4	51.4	70	1.059	52.8	72	1.118	1.056
5	51.1	47	1.043	72.5	80	2.636	2.527
6	58.6	58	1.417	59.3	81	1.455	1.027
7	25.8	62	0.348	65.0	60	1.857	5.336
8	59.7	67	1.481	61.4	83	1.594	1.076
9	42.0	69	0.725	36.0	75	0.563	0.777
10	38.1	63	0.615	36.4	66	0.571	0.928
11	42.6	68	0.744	60.6	66	1.538	2.067

Overall odds ratio adjusted for blocks 2-11 (95% LRCI) 1.418(0.991-2.032)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.06

Juvenile bypass efficiency

	00/45			00/60			Observed
Block	JBYPE	N	Odds	JBYPE	N	Odds	odds ratio
2	28.1	57	0.390	30.6	49	0.441	1.131
3	34.1	44	0.517	20.4	54	0.256	0.495
4	37.1	70	0.591	31.9	72	0.469	0.794
5	29.8	47	0.424	16.3	80	0.194	0.458
6	24.1	58	0.318	29.6	81	0.421	1.324
7	45.2	62	0.824	15.0	60	0.176	0.214
8	26.9	67	0.367	22.9	83	0.297	0.809
9	40.6	69	0.683	49.3	75	0.974	1.426
10	46.0	63	0.853	51.5	66	1.062	1.245
11	45.6	68	0.838	21.2	66	0.269	0.321

Overall odds ratio adjusted for blocks 2-11 (95% LRCI) 0.738(0.496-1.096)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.13

Appendix F. Diel estimates of yearling Chinook salmon fish passage efficiency (FPE) during 00/60 and 00/45 spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 28 April through 07 June 2003. LRCI = likelihood ratio confidence interval. N = sample size.

Day							
	00/45			00/60			Observed odds ratio
Block	FPE	N	Odds	FPE	N	Odds	
2	76.9	13	3.333	81.8	11	4.500	1.350
3	76.9	13	3.333	50.0	12	1.000	0.300
4	72.4	29	2.625	82.6	23	4.750	1.810
5	66.7	18	2.000	56.3	16	1.286	0.643
6	69.2	13	2.250	83.3	24	5.000	2.222
7	91.3	23	10.500	50.0	12	1.000	0.095
8	76.2	21	3.200	71.4	21	2.500	0.781
9	83.3	18	5.000	81.6	38	4.429	0.886
10	84.0	25	5.250	86.5	37	6.400	1.219
11	85.2	27	5.750	60.0	10	1.500	0.261
Overall odds ratio adjusted for blocks 2-11 (95% LRCI)							0.727(0.445-1.181)
Test HO: odds ratio = 1 (no treatment effect), $P = 0.33$							

Night							
	00/45			00/60			Observed Odds Ratio
Block	FPE	N	Odds	FPE	N	Odds	
2	88.6	44	7.8	92.1	38	11.666	1.496
3	87.1	31	6.750	95.2	42	20.000	2.963
4	100.0	41	-	85.7	49	6.000	-
5	89.7	29	8.667	96.9	64	31.000	3.577
6	86.7	45	6.500	91.2	57	10.400	1.600
7	59.0	39	1.437	87.5	48	7.000	4.871
8	91.3	46	10.500	88.7	62	7.857	0.748
9	82.4	51	4.667	89.2	37	8.250	1.768
10	84.2	38	5.334	89.7	29	8.667	1.625
11	90.2	41	9.250	85.7	56	6.000	0.649
Overall odds ratio adjusted for blocks 2-11 (95% LRCI)							1.462(0.765-2.817)
Test HO: odds ratio = 1 (no treatment effect), $P = 0.25$							

Appendix G. Estimates of yearling Chinook salmon spill passage efficiency (SPE) during 45 and 60% spill (i.e., night conditions) by block at John Day Dam and logistic regression results comparing the two night spill levels, 28 April through 07 June 2003. LRCI = likelihood ratio confidence interval. N = sample size.

	Spill Treatment						
	45%			60%			Observed odds ratio
Block	SPE	N	Odds	SPE	N	Odds	
2	75.0	44	3.000	76.3	38	3.222	1.074
3	71.0	31	2.444	83.3	42	5.000	2.046
4	87.8	41	7.200	77.6	49	3.455	0.480
5	82.8	29	4.800	90.6	64	9.667	2.014
6	75.6	45	3.091	84.2	57	5.334	1.726
7	41.0	39	0.696	81.3	48	4.333	6.226
8	87.0	46	6.667	82.3	62	4.636	0.695
9	56.9	51	1.318	73.0	37	2.700	2.049
10	55.3	38	1.235	79.3	29	3.833	3.104
11	70.7	41	2.417	71.4	56	2.500	1.034
Overall odds ratio adjusted for blocks 2-11 (95% LRCI)							1.639(1.037-2.604)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.03							

Appendix H. Diel estimates of yearling Chinook salmon juvenile fish bypass passage efficiency (JBYPE) during 00/60 and 00/45 spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 28 April through 07 June 2003. LRCI = likelihood ratio confidence interval. N = sample size.

Day							
	00/45			00/60			Observed odds ratio
Block	JBYPE	N	Odds	JBYPE	N	Odds	
2	76.9	13	3.333	81.8	11	4.500	1.350
3	76.9	13	3.333	50.0	12	1.000	0.300
4	72.4	29	2.625	82.6	23	4.750	1.810
5	66.7	18	2.000	56.3	16	1.286	0.643
6	69.2	13	2.250	83.3	24	5.000	2.222
7	91.3	23	10.500	50.0	12	1.000	0.095
8	76.2	21	3.200	71.4	21	2.500	0.781
9	83.3	18	5.000	81.6	38	4.429	0.886
10	72.0	25	2.571	83.8	37	5.167	2.010
11	85.2	27	5.750	60.0	10	1.500	0.261
Overall odds ratio adjusted for blocks 2-11 (95% LRCI)							0.799(0.495-1.284)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.35							

Night							
	00/45			00/60			Observed odds ratio
Block	JBYPE	N	Odds	JBYPE	N	Odds	
2	13.6	44	0.158	15.789	38	0.187	1.184
3	16.1	31	0.192	11.905	42	0.135	0.703
4	12.2	41	0.139	8.163	49	0.089	0.640
5	6.9	29	0.074	6.250	64	0.067	0.905
6	11.1	45	0.125	7.018	57	0.075	0.600
7	17.9	39	0.219	6.250	48	0.067	0.306
8	4.3	46	0.045	6.452	62	0.069	1.533
9	25.5	51	0.342	16.216	37	0.194	0.567
10	28.9	38	0.407	10.345	29	0.115	0.283
11	19.5	41	0.242	14.286	56	0.167	0.690
Overall odds ratio adjusted for blocks 2-11 (95% LRCI)							0.631(0.417-0.950)
Test HO: odds ratio=1 (no treatment effect), *P* = 0.03							

Appendix I. Release date, release time (hours), sample size (N),percent detected (% Det.), mean, standard deviation (SD), and range of fork lengths (mm) and weights (g) of subyearling Chinook salmon released into Rock Creek above John Day Dam during summer 2003.

Release date	Release time	N	% Det.	Fork Length (mm) Mean	SD	Range	Weight (g) Mean	SD	Range
22 June	0900	59	91.5	114	3.0	110-124	15.2	1.5	13.1-20.0
22 June	2100	71	97.2	114	4.1	110-127	15.5	2.2	11.8-23.0
23 June	0900	65	93.9	115	4.8	110-141	15.8	2.8	13.3-31.5
23 June	2100	66	93.9	115	5.1	110-134	15.6	2.5	12.9-24.0
24 June	0900	75	96.0	115	3.3	110-124	15.0	1.4	12.1-21.0
24 June	2100	67	91.0	115	3.8	110-127	15.2	1.9	13.0-21.4
25 June	0900	72	95.8	115	3.6	110-128	15.6	1.8	13.1-22.4
25 June	2100	67	91.0	114	2.7	111-122	14.3	1.2	13.0-17.9
26 June	0900	72	97.2	115	3.3	111-126	15.3	1.8	12.6-21.1
26 June	2100	70	88.6	115	4.0	110-132	15.5	1.8	13.0-23.8
27 June	0900	72	95.8	115	3.1	110-126	15.6	1.4	13.2-19.9
27 June	2100	70	94.3	114	2.5	110-122	14.7	1.2	12.9-19.1
28 June	0900	73	100.0	115	3.2	110-125	15.4	1.7	13.0-21.7
28 June	2100	70	95.7	115	3.9	110-137	14.6	2.1	13.0-27.0
29 June	0900	75	90.7	114	2.6	110-122	15.0	1.4	13.0-18.2
29 June	2100	72	93.1	115	4.1	110-132	15.7	2.2	13.2-25.2
30 June	0900	69	97.1	115	4.1	110-129	14.7	2.0	13.0-24.8
30 June	2100	69	89.9	114	2.9	110-122	15.5	1.6	12.9-20.2
01 July	0900	68	97.1	115	3.6	110-128	15.1	2.0	13.0-22.4
01 July	2100	70	88.6	115	4.0	110-130	16.3	2.4	13.1-25.0
02 July	0900	73	89.0	115	3.8	110-127	15.6	2.6	13.0-25.9
02 July	2100	67	83.6	115	4.3	110-135	15.0	2.3	13.0-26.1
03 July	0900	62	91.9	115	5.3	110-131	16.2	3.1	13.1-25.8
03 July	2100	71	84.5	117	4.9	110-139	16.1	2.9	13.1-30.8
04 July	0900	72	84.7	115	4.5	109-130	16.5	2.3	13.3-24.5
04 July	2100	76	86.8	117	4.5	110-133	15.7	2.1	13.2-24.4
05 July	0900	75	78.7	115	4.6	110-127	16.5	2.4	13.2-22.8
05 July	2100	73	80.8	115	4.0	110-129	15.8	1.9	13.1-23.3
06 July	0900	74	89.2	116	4.9	110-139	15.4	2.3	13.0-24.8
06 July	2100	76	86.8	117	5.1	110-138	16.8	2.7	13.1-27.4
07 July	0900	73	84.9	117	5.2	110-140	16.1	2.6	13.1-26.8
07 July	2100	76	89.5	116	5.4	110-133	16.6	2.7	13.2-25.2
08 July	0900	75	89.3	117	4.5	110-132	15.8	2.1	13.1-21.7
08 July	2100	74	81.1	114	4.9	110-134	16.6	2.6	13.3-26.6
09 July	0900	75	89.3	117	5.0	110-134	17.1	2.7	13.7-25.1
09 July	2100	76	77.6	114	4.5	110-137	16.2	2.3	13.1-27.5
10 July	0900	74	89.2	116	4.9	110-133	16.8	2.7	13.4-26.2
10 July	2100	69	76.8	116	6.5	110-145	17.1	3.3	13.3-34.1
11 July	0900	72	70.8	115	4.6	110-129	16.4	2.3	13.1-22.2
11 July	2100	75	80.0	116	6.1	110-142	16.0	2.7	13.2-24.8
12 July	0900	76	79.0	115	5.3	109-132	16.8	2.6	13.2-26.9
12 July	2100	76	75.0	120	9.1	110-145	17.4	4.1	13.0-29.9
13 July	0900	75	70.7	121	9.1	111-145	19.0	4.2	14.0-30.7
13 July	2100	75	42.7	120	7.9	110-147	17.3	3.6	13.0-32.3
14 July	0900	76	75.0	122	9.3	110-147	19.0	4.3	13.7-31.8
14 July	2100	75	54.7	120	9.0	110-153	19.0	4.5	13.6-37.0
15 July	0900	76	79.0	121	8.4	111-150	17.7	3.9	13.4-34.0
15 July	2100	76	51.3	118	7.3	110-145	17.9	3.8	13.2-32.4

Appendix I continued.

Release date	Release time	N	% Det	Fork Length (mm)			Weight (g)		
				Mean	SD	Range	Mean	SD	Range
16 July	0900	126	77.0	120	10.2	110-152	18.9	4.9	14.0-37.2
16 July	2100	75	65.3	119	8.8	110-152	18.5	4.3	13.7-35.9
17 July	0900	73	68.5	119	8.8	110-150	17.8	4.1	13.0-37.1
17 July	2100	99	62.6	121	8.6	110-151	19.7	4.3	14.0-38.9
18 July	0900	73	72.6	122	9.3	110-145	19.3	4.2	13.9-35.0
18 July	2100	74	63.5	119	7.1	111-148	18.9	4.0	13.5-37.1
19 July	0900	74	64.9	117	6.8	110-148	17.1	3.2	13.3-32.9
19 July	2100	73	61.6	117	7.7	110-150	18.3	3.8	13.7-36.4
	Overall:	4122	82.1	117	6.3	109-153	16.6	3.2	11.8-38.9

Appendix J. Subyearling Chinook salmon spillway (SP), powerhouse (PH), and juvenile fish bypass (JBS) passage counts by block, treatment, date, and diel at John Day Dam, summer 2003.

Species	Block	Trt	Date	Diel	SP	PH	JBS
CH0	5	12 h	6/25/03	Day	0	15	18
CH0	5	12 h	6/25/03	Night	68	3	2
CH0	5	12 h	6/26/03	Day	0	10	19
CH0	5	12 h	6/26/03	Night	113	19	9
CH0	5	12 h	6/27/03	Night	38	8	0
CH0	5	24 h	6/27/03	Day	44	4	8
CH0	5	24 h	6/27/03	Night	11	3	6
CH0	5	24 h	6/28/03	Day	52	5	4
CH0	5	24 h	6/28/03	Night	25	23	7
CH0	5	24 h	6/29/03	Night	23	13	9
CH0	6	12 h	7/1/03	Day	0	23	19
CH0	6	12 h	7/1/03	Night	43	12	2
CH0	6	12 h	7/2/03	Day	0	19	20
CH0	6	12 h	7/2/03	Night	52	6	1
CH0	6	12 h	7/3/03	Night	17	2	2
CH0	6	24 h	6/29/03	Day	63	3	5
CH0	6	24 h	6/29/03	Night	7	5	3
CH0	6	24 h	6/30/03	Day	57	3	1
CH0	6	24 h	6/30/03	Night	36	12	11
CH0	6	24 h	7/1/03	Night	12	15	5
CH0	7	12 h	7/5/03	Day	0	27	25
CH0	7	12 h	7/5/03	Night	31	2	3
CH0	7	12 h	7/6/03	Day	0	24	26
CH0	7	12 h	7/6/03	Night	29	8	6
CH0	7	12 h	7/7/03	Night	9	6	0
CH0	7	24 h	7/3/03	Day	58	9	3
CH0	7	24 h	7/3/03	Night	6	4	1
CH0	7	24 h	7/4/03	Day	57	15	5
CH0	7	24 h	7/4/03	Night	20	10	1
CH0	7	24 h	7/5/03	Night	11	14	2
CH0	8	12 h	7/7/03	Day	0	29	19
CH0	8	12 h	7/7/03	Night	31	4	4
CH0	8	12 h	7/8/03	Day	0	18	12
CH0	8	12 h	7/8/03	Night	37	3	4
CH0	8	12 h	7/9/03	Night	53	5	1
CH0	8	24 h	7/9/03	Day	73	23	23

Appendix J. Continued.

Species	Block	Trt	Date	Diel	SP	PH	JBS
CH0	8	24 h	7/9/03	Night	36	16	5
CH0	8	24 h	7/10/03	Day	41	22	13
CH0	8	24 h	7/10/03	Night	24	35	18
CH0	8	24 h	7/11/03	Night	7	13	13
CH0	9	12 h	7/11/03	Day	0	28	35
CH0	9	12 h	7/11/03	Night	7	2	3
CH0	9	12 h	7/12/03	Day	0	22	23
CH0	9	12 h	7/12/03	Night	36	4	5
CH0	9	12 h	7/13/03	Night	33	6	1
CH0	9	24 h	7/13/03	Day	55	19	6
CH0	9	24 h	7/13/03	Night	11	3	1
CH0	9	24 h	7/14/03	Day	41	11	7
CH0	9	24 h	7/14/03	Night	34	16	8
CH0	9	24 h	7/15/03	Night	10	11	0
CH0	10	12 h	7/15/03	Day	0	21	20
CH0	10	12 h	7/15/03	Night	6	3	1
CH0	10	12 h	7/16/03	Day	0	24	17
CH0	10	12 h	7/16/03	Night	24	13	0
CH0	10	12 h	7/17/03	Night	16	6	4
CH0	10	24 h	7/17/03	Day	60	21	11
CH0	10	24 h	7/17/03	Night	15	3	3
CH0	10	24 h	7/18/03	Day	40	13	7
CH0	10	24 h	7/18/03	Night	18	13	5
CH0	10	24 h	7/19/03	Night	11	9	4
CH0	11	12 h	7/21/03	Day	0	16	10
CH0	11	12 h	7/21/03	Night	10	0	1
CH0	11	12 h	7/22/03	Day	0	11	2
CH0	11	12 h	7/22/03	Night	15	2	2
CH0	11	12 h	7/23/03	Night	5	1	1
CH0	11	24 h	7/19/03	Day	31	18	6
CH0	11	24 h	7/19/03	Night	2	4	1
CH0	11	24 h	7/20/03	Day	34	19	12
CH0	11	24 h	7/20/03	Night	13	11	5
CH0	11	24 h	7/21/03	Night	6	5	2

Appendix K. Percentage of time main turbine units 1 through 16 (MU1-MU16) and spill bays 1 through 20 (SB1-SB20) were in operation during the 12-h treatment by block at John Day Dam, summer 2003. Darker shading indicates greater percentage.

	Block													
	Day							Night						
Unit	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MU1	100	100	100	100	100	93		100	100	100	100	100	100	
MU2	100	96	100	100	100	91		100	100	71	92	100	100	
MU3	100	97	100	100	100	100		100	24	100	100	100	100	
MU4	100	100	97	100	100	100		83	100	18	66	37	42	
MU5	100	100	100	100	100	100		100	100	100	100	100	100	
MU6	88	49	0	9	41	40		4	0	0	5	0	0	
MU7	60	46	46	0	3	68		19	0	0	3	0	0	
MU8	100	90	74	57	93	95		19	8	4	0	9	3	
MU9	92	96	92	47	92	35		17	17	4	8	4	0	
MU10	93	92	46	8	93	75		23	0	0	0	4	0	
MU11	96	92	0	47	0	46		28	10	0	9	0	8	
MU12	90	0	0	43	0	23		11	0	0	1	0	0	
MU13	0	0	0	0	0	0		0	0	0	0	0	0	
MU14	90	94	0	70	0	29		29	9	0	10	0	8	
MU15	14	23	93	46	79	65		0	0	5	0	0	0	
MU16	95	92	0	11	93	65		35	4	0	5	5	0	
SB1	6	2	2	1	2	1		17	3	1	1	3	0	
SB2	9	8	8	8	8	7		96	92	91	96	96	95	
SB3	8	8	7	8	8	7		96	92	91	98	96	95	
SB4	8	10	7	8	8	7		96	92	91	96	96	95	
SB5	8	10	7	8	8	8		96	92	91	96	95	95	
SB6	8	8	7	8	8	7		96	92	91	96	96	95	
SB7	8	8	7	8	9	8		95	91	73	96	96	95	
SB8	8	8	7	8	8	7		96	91	73	96	96	95	
SB9	8	8	7	8	8	7		95	91	50	96	95	95	
SB10	10	10	8	9	10	10		96	91	51	96	96	95	
SB11	8	8	7	8	8	7		95	91	50	95	91	95	
SB12	8	8	7	8	8	7		96	91	50	95	91	91	
SB13	11	8	11	10	10	9		96	91	61	95	92	91	
SB14	8	9	8	10	9	9		95	91	45	96	92	95	
SB15	8	8	7	8	8	7		91	91	45	91	91	91	
SB16	8	8	4	8	8	7		91	91	28	91	91	91	
SB17	8	8	4	8	8	7		91	90	28	90	91	63	
SB18	8	8	4	8	8	7		73	59	27	77	90	63	
SB19	8	4	4	4	8	7		71	45	14	27	41	18	
SB20	8	4	4	4	5	7		68	18	14	14	23	18	

Appendix L. Percentage of time main turbine units 1 through 16 (MU1-MU16) and spill bays 1 through 20 (SB1-SB20) were in operation during 24-h 30% spill by block at John Day Dam, summer 2003. Darker shading indicates greater percentage.

	Blocks													
	Day							Night						
Unit	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MU1	100	100	100	100	100	100	100	100	100	100	100	97	100	100
MU2	100	100	100	100	100	100	100	100	84	100	100	100	100	100
MU3	100	100	84	100	100	100	100	100	100	100	100	91	81	100
MU4	100	99	100	100	100	100	87	100	100	100	100	100	100	100
MU5	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MU6	0	0	0	13	15	0	0	0	16	0	9	9	3	0
MU7	26	0	34	63	49	50	50	19	0	50	39	17	55	33
MU8	69	100	0	50	50	0	1	61	72	0	18	50	0	0
MU9	46	33	42	17	50	45	43	78	49	50	50	23	18	22
MU10	27	33	1	62	0	0	0	19	23	51	42	13	0	0
MU11	100	100	5	50	5	21	2	74	43	0	18	11	6	0
MU12	0	0	0	14	2	18	4	0	0	0	19	0	14	0
MU13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU14	99	100	0	69	0	58	0	75	69	0	23	2	17	0
MU15	4	19	0	0	50	0	0	10	18	7	0	22	0	0
MU16	80	33	0	81	36	34	0	64	18	36	90	50	9	0
SB1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SB2	100	100	100	100	100	100	100	100	95	95	91	95	100	100
SB3	100	100	100	100	100	100	100	100	96	95	91	95	100	100
SB4	100	100	100	99	100	100	100	100	100	95	91	95	100	100
SB5	100	100	100	99	100	100	100	100	100	95	91	95	100	100
SB6	100	100	100	100	100	100	100	100	96	95	91	95	100	100
SB7	100	100	100	100	100	100	100	100	95	95	91	95	100	100
SB8	100	100	100	100	100	100	100	100	95	95	91	95	85	100
SB9	100	100	93	100	100	100	88	100	93	95	84	86	85	100
SB10	100	100	90	100	97	100	94	98	94	95	86	87	75	100
SB11	100	100	35	100	85	64	54	73	78	81	73	65	51	100
SB12	100	100	12	95	85	48	43	72	58	81	63	59	42	26
SB13	87	95	36	97	63	67	65	81	64	58	59	48	47	36
SB14	82	71	3	81	53	51	4	61	49	9	65	33	25	2
SB15	51	62	0	52	20	21	0	54	30	5	23	14	12	0
SB16	47	36	0	46	23	7	0	36	13	0	23	14	9	0
SB17	39	8	0	26	4	1	0	13	13	0	9	9	9	0
SB18	27	0	1	0	1	0	1	10	0	0	0	1	0	1
SB19	3	0	0	0	0	0	0	4	0	0	0	0	0	0
SB20	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix M. Estimates of subyearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass passage efficiency (JBYPE) during 12- and 24-h spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 25 June through 23 July 2003. LRCI = likelihood ratio confidence interval. N = sample size.

Fish passage efficiency							
	12-h			24-h			Observed
Block	FPE	N	Odds	FPE	N	Odds	odds ratio
5	82.7	324	4.786	79.4	238	3.857	0.806
6	70.9	220	2.437	84.0	238	5.263	2.160
7	65.5	197	1.897	75.9	216	3.154	1.663
8	72.9	221	2.683	69.5	364	2.279	0.849
9	69.4	206	2.270	74.2	233	2.883	1.270
10	56.1	157	1.275	74.7	233	2.949	2.313
11	60.5	76	1.533	66.3	169	1.965	1.282
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)							1.339(0.974-1.840)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.07							

Spill passage efficiency							
	12-h			24-h			Observed
Block	SPE	N	Odds	SPE	N	Odds	odds ratio
5	67.9	324	2.115	65.1	238	1.867	0.883
6	50.9	220	1.037	73.5	238	2.778	2.679
7	35.0	197	0.539	70.4	216	2.375	4.406
8	54.8	221	1.210	49.7	364	0.989	0.817
9	36.9	206	0.585	64.8	233	1.841	3.147
10	29.3	157	0.414	61.8	233	1.618	3.908
11	39.5	76	0.652	50.9	169	1.036	1.589
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)							1.942(1.136-3.354)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.02							

Juvenile bypass passage efficiency							
	12-h			24-h			Observed
Block	JBYPE	N	Odds	JBYPE	N	Odds	odds ratio
5	14.8	324	0.174	14.3	238	0.167	0.960
6	20.0	220	0.250	10.5	238	0.117	0.468
7	30.5	197	0.438	5.6	216	0.059	0.135
8	18.1	221	0.221	19.8	364	0.247	1.118
9	32.5	206	0.482	9.4	233	0.104	0.216
10	26.8	157	0.365	12.9	233	0.148	0.405
11	21.1	76	0.267	15.4	169	0.182	0.682
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)							0.491 (0.277-0.857)
Test HO: odds ratio = 1 (no treatment effect), *P* = 0.01							

Appendix N. Diel estimates of subyearling Chinook salmon fish passage efficiency (FPE) during 12- and 24-h spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 25 June through 23 July 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at $\alpha = 0.05$ level.

Day							
	12-h			24-h			Observed odds ratio
Block	FPE	N	Odds	FPE	N	Odds	
5	59.7	62	1.481	92.3	117	11.987	8.094
6	47.6	82	0.908	95.5	132	21.222	23.372
7	49.5	103	0.980	83.7	147	5.135	5.240
8	39.2	79	0.645	76.5	196	3.255	5.047
9	53.2	109	1.137	78.4	139	3.630	3.193
10	44.6	83	0.805	77.6	152	3.464	4.303
11	30.8	39	0.445	69.2	120	2.247	5.049
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)						5.483(3.669-8.290)	
Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$							

Night							
	12-h			24-h			Observed odds ratio
Block	FPE	N	Odds	FPE	N	Odds	
5	88.2	262	7.475	66.9	121	2.021	0.270
6	84.8	138	5.579	69.8	106	2.311	0.414
7	83.0	94	4.882	59.4	69	1.463	0.300
8	91.5	142	10.765	61.3	168	1.584	0.147
9	87.6	97	7.065	68.1	94	2.135	0.302
10	68.9	74	2.215	69.1	81	2.236	1.009
11	91.9	37	11.346	59.2	49	1.451	0.128
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)						0.309(0.193-0.487)	
Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$							

Appendix O. Diel estimates of subyearling Chinook salmon spill passage efficiency (SPE) during 12- and 24-h spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments at night, 25 June through 23 July 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at α = 0.05 level.

Spill Treatment							
	12-h			24-h			Observed odds ratio
Block	SPE	N	Odds	SPE	N	Odds	
5	84.0	262	5.250	48.8	121	0.953	0.182
6	81.2	138	4.319	51.9	106	1.079	0.250
7	73.4	94	2.759	53.6	69	1.155	0.419
8	85.2	142	5.757	39.9	168	0.664	0.115
9	78.4	97	3.630	58.5	94	1.410	0.388
10	62.2	74	1.646	54.3	81	1.188	0.722
11	81.1	37	4.291	42.9	49	0.751	0.175
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)							0.251(0.157-0.397)
Test HO: odds ratio = 1 (no treatment effect), *P* < 0.0001							

Appendix P. Diel estimates of subyearling Chinook salmon juvenile fish bypass passage efficiency (JBYPE) during 12- and 24-h spill treatments by block at John Day Dam and logistic regression results comparing the two spill treatments, 25 June through 23 July 2003. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass passage efficiency. N = sample size. LRCI = likelihood ratio confidence interval. * = significant treatment effect at $\alpha = 0.05$ level.

Day							
	12-h			24-h			Observed odds ratio
Block	JBYPE	N	Odds	JBYPE	N	Odds	
5	59.7	62	1.481	10.3	117	0.115	0.078
6	47.6	82	0.908	4.5	132	0.047	0.052
7	49.5	103	0.980	5.4	147	0.057	0.058
8	39.2	79	0.645	18.4	196	0.225	0.349
9	53.2	109	1.137	9.4	139	0.104	0.091
10	44.6	83	0.805	11.8	152	0.134	0.166
11	30.8	39	0.445	15.0	120	0.176	0.396
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)						0.134(0.074-0.237)	
Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$							

Night							
	12-h			24-h			Observed odds ratio
Block	JBYPE	N	Odds	JBYPE	N	Odds	
5	4.2	262	0.044	18.2	121	0.222	5.045
6	3.6	138	0.037	17.9	106	0.218	5.892
7	9.6	94	0.106	5.8	69	0.062	0.585
8	6.3	142	0.067	21.4	168	0.272	4.060
9	9.3	97	0.103	9.6	94	0.106	1.029
10	6.8	74	0.073	14.8	81	0.174	2.384
11	10.8	37	0.121	16.3	49	0.195	1.612
Overall odds ratio adjusted for blocks 5-11 (95% LRCI)						2.794(1.558-5.179)	
Test HO: odds ratio = 1 (no treatment effect), $P = 0.0005$							